10/721 227

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Search Results - Record(s) 1 through 10 of 40 returned.

☐ 1. Document ID: US 20030209893 A1

Using default format because multiple data bases are involved.

L20: Entry 1 of 40 File: PGPB Nov 13, 2003

PGPUB-DOCUMENT-NUMBER: 20030209893
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030209893 A1

TITLE: Occupant sensing system

PUBLICATION-DATE: November 13, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Breed, David S.	Boonton Township	NJ	US	
DuVall, Wilbur E.	Kimberling City	MO	US	
Johnson, Wendell C.	Signal Hill	CA	US	

US-CL-CURRENT: 280/735; 701/45

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw. De

☐ 2. Document ID: US 20030208316 A1

L20: Entry 2 of 40 File: PGPB Nov 6, 2003

PGPUB-DOCUMENT-NUMBER: 20030208316
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030208316 A1

TITLE: Bird's-eye view forming method, map display apparatus and navigation system

PUBLICATION-DATE: November 6, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Endo, Yoshinori	Mito-shi		JP	
Fujiwara, Toshio	Hitachi-shi		JP	
Satake, Hiroyuki	Hitachi-shi		JP	
Shojima, Hiroshi	Kashiwa-shi		JP	
Kishi, Norimasa	Yokohama-shi		JP	

Watanabe, Masaki	Yokohama-shi	JP
Hirano, Motoki	Tokyo	JP

US-CL-CURRENT: 701/211; 340/995.12

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 3. Document ID: US 20030192375 A1

L20: Entry 3 of 40 File: PGPB Oct 16, 2003

PGPUB-DOCUMENT-NUMBER: 20030192375
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030192375 A1

TITLE: Physical quantity estimating apparatus and tire state determining apparatus, and estimating method of same and determination method of same

PUBLICATION-DATE: October 16, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Sugai, Masaru	Aichi-gun		JP	
Asano, Katsuhiro	Toyoake-shi		JP	
Umeno, Takaji	Nisshin-shi		JP	

US-CL-CURRENT: 73/146; 701/80

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 4. Document ID: US 20030176961 A1

L20: Entry 4 of 40 File: PGPB Sep 18, 2003

PGPUB-DOCUMENT-NUMBER: 20030176961
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030176961 A1

TITLE: System and method for controlling and/or regulating the handling characteristics of a motor vehicle

PUBLICATION-DATE: September 18, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Sauter, Thomas	Remseck		DE	
Zoebele, Andreas	Markgroeningen		DE	
Schmitt, Johannes	Markgroenigen		DE	
Haas, Hardy	Markgroeningen		DE	

US-CL-CURRENT: 701/70; 701/71, 701/82

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 5. Document ID: US 20030172728 A1

L20: Entry 5 of 40 File: PGPB Sep 18, 2003

PGPUB-DOCUMENT-NUMBER: 20030172728
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030172728 A1

TITLE: Tire pressure estimation

PUBLICATION-DATE: September 18, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Gustafsson, Fredrik	Ljungsbro		SE	
Drevo, Marcus	Linkoping		SE	
Persson, Niclas	Linkoping		SE	

US-CL-CURRENT: 73/146

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 6. Document ID: US 20030163255 A1

L20: Entry 6 of 40 File: PGPB Aug 28, 2003

PGPUB-DOCUMENT-NUMBER: 20030163255
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030163255 A1

TITLE: Location equipment

PUBLICATION-DATE: August 28, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Ishigami, Tadatomi	Tokyo		JP	
Mikuriya, Makoto	Tokyo		JP	
Shimotani, Mitsuo	Tokyo		JP	
Akamatsu, Teruki	Tokyo		JP	
Matsuo, Toshiyuki	Hyogo		JP	

US-CL-CURRENT: 701/213; 340/988, 342/357.06

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

7. Document ID: US 20030156324 A1

L20: Entry 7 of 40 File: PGPB Aug 21, 2003

PGPUB-DOCUMENT-NUMBER: 20030156324
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030156324 A1

TITLE: AUTOMATED TELESCOPE WITH DISTRIBUTED ORIENTATION AND OPERATION PROCESSING

PUBLICATION-DATE: August 21, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Baun, Kenneth W.	Trabuco Canyon	CA	US	
Smith, John E.	Mission Viejo	CA	US	
Hoot, John E.	San Clemente	CA	US	
Wachala, Michael A.	Riverside	CA	US	
Tingey, Brian G.	Fountain Valley	CA	US	
Duchon, Brent G.	Garden Grove	CA	US	
Dewan, Stanley H.	Rancho Santa Margarita	CA	US	

US-CL-CURRENT: 359/430; 359/399, 359/405, 359/409

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

8. Document ID: US 20030130779 A1

L20: Entry 8 of 40 File: PGPB Jul 10, 2003

PGPUB-DOCUMENT-NUMBER: 20030130779
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030130779 A1

TITLE: Control apparatus and applicable control method and control program for vehicle

PUBLICATION-DATE: July 10, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Shiimado, Toshihiro	Anjo-shi		JP	
Okasaka, Kazuomi	Anjo-shi		JP	
Imanaga, Yuuji	Anjo-shi		JP	
Tamura, Tadashi	Toyota-shi		JP	
Inoue, Daisuke	Toyota-shi		JP	
Taniguchi, Hiroji	Toyota-shi		JP	
Ogawa, Fumiharu	Hekinan-shi		JP	

US-CL-CURRENT: 701/65; 701/51

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KWIC	Draw De

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☐ 9. **Document ID: US 20030120183 A1**

L20: Entry 9 of 40 File: PGPB Jun 26, 2003

PGPUB-DOCUMENT-NUMBER: 20030120183
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030120183 A1

TITLE: Assistive clothing

PUBLICATION-DATE: June 26, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Simmons, John C.	Germantown	TN	US	

US-CL-CURRENT: 600/595

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KWIC	Draw De

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☐ 10. **Document ID: US 20030117015 A1**

L20: Entry 10 of 40 File: PGPB Jun 26, 2003

PGPUB-DOCUMENT-NUMBER: 20030117015
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030117015 A1

TITLE: Brake control device, brake control method, and recording medium

PUBLICATION-DATE: June 26, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Kuwajima, Masatoshi	Kanagawa		JP	
Kogure, Tomohiko	Kanagawa		JP	

US-CL-CURRENT: 303/150; 303/163

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KWIC	Draw De

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Terms	Documents
L19 and distance	40

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Search Results - Record(s) 11 through 20 of 40 returned.

☐ 11. Document ID: US 20030093188 A1

Using default format because multiple data bases are involved.

L20: Entry 11 of 40 File: PGPB May 15, 2003

PGPUB-DOCUMENT-NUMBER: 20030093188
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030093188 A1

TITLE: Rotation-speed sensor device

PUBLICATION-DATE: May 15, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Morita, Kouichi	Fujisawa-shi		JP	
Sakatani, Ikunori	Fujisawashi		JP	
Endo, Shigeru	Fujisawa-shi		JP	
Miyazaki, Hiroya	Fujisawa-shi		JP	
Sakamoto, Junshi	Fujisawa-shi		JP	
Nakamura, Yuji	Fujisawa-shi		JP	

US-CL-CURRENT: 701/1; 340/438, 701/29, 701/71

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

☐ 12. Document ID: US 20030080857 A1

L20: Entry 12 of 40 File: PGPB May 1, 2003

PGPUB-DOCUMENT-NUMBER: 20030080857
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030080857 A1

TITLE: Process and system for determining the onset of tread rubber separations of a pneumatic tire on a vehicle

PUBLICATION-DATE: May 1, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Hartmann, Bernd	Bad Nenndorf		DE	

Kobe, Andreas	Bensheim	DE

US-CL-CURRENT: 340/425.5; 340/435

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw. De

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☐ 13. Document ID: US 20030056386 A1

L20: Entry 13 of 40 File: PGPB Mar 27, 2003

PGPUB-DOCUMENT-NUMBER: 20030056386
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030056386 A1

TITLE: Apparatus and method to measure the dimensional and form deviation of crankpins at the place of grinding

PUBLICATION-DATE: March 27, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Danielli, Franco	Zola Predosa		IT	
Dall'Aglio, Carlo	Castello D'Argile		IT	

US-CL-CURRENT: 33/555.1

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw. De

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☐ 14. Document ID: US 20030055543 A1

L20: Entry 14 of 40 File: PGPB Mar 20, 2003

PGPUB-DOCUMENT-NUMBER: 20030055543
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030055543 A1

TITLE: Robust steerling-pull torque compensation

PUBLICATION-DATE: March 20, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Amberkar, Sanket S.	Ann Arbor	MI	US	
Chandy, Ashok	Fenton	MI	US	
Pattok, Kathryn L.	Saginaw	MI	US	
Colosky, Mark P.	Vassar	MI	US	

US-CL-CURRENT: 701/41; 180/446, 477/1

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw. De

☐ 15. Document ID: US 20030050743 A1

L20: Entry 15 of 40 File: PGPB Mar 13, 2003

PGPUB-DOCUMENT-NUMBER: 20030050743
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030050743 A1

TITLE: Method and system for controlling the behaviour of a vehicle by controlling its tyres

PUBLICATION-DATE: March 13, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Caretta, Renato	Gallarate		IT	
Cesarini, Riccardo	Bergamo		IT	
Mancosu, Federico	Milano		IT	

US-CL-CURRENT: 701/1; 340/442

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

☐ 16. Document ID: US 20030036847 A1

L20: Entry 16 of 40 File: PGPB Feb 20, 2003

PGPUB-DOCUMENT-NUMBER: 20030036847
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030036847 A1

TITLE: POSITION AND HEADING ERROR-CORRECTION METHOD AND APPARATUS FOR VEHICLE NAVIGATION SYSTEMS

PUBLICATION-DATE: February 20, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Geier, George J.	Scottsdale	AZ	US	
Figor, Russel S.	Mesa	AZ	US	
Strother, Troy L.	Tempe	AZ	US	

US-CL-CURRENT: 701/209; 701/210

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

☐ 17. Document ID: US 20030034884 A1

L20: Entry 17 of 40 File: PGPB Feb 20, 2003

PGPUB-DOCUMENT-NUMBER: 20030034884
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030034884 A1

TITLE: Method and apparatus for detecting decrease in tire air-pressure, and selecting program for thresholds for judging decompression of tire

PUBLICATION-DATE: February 20, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Oshiro, Yuji	Kobe-shi		JP	

US-CL-CURRENT: 340/443

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 18. Document ID: US 20030030774 A1

L20: Entry 18 of 40 File: PGPB Feb 13, 2003

PGPUB-DOCUMENT-NUMBER: 20030030774
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030030774 A1

TITLE: Clinical refractive instruments

PUBLICATION-DATE: February 13, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Raasch, Thomas W.	Upper Arlington	OH	US	

US-CL-CURRENT: 351/205; 351/216

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 19. Document ID: US 20030024308 A1

L20: Entry 19 of 40 File: PGPB Feb 6, 2003

PGPUB-DOCUMENT-NUMBER: 20030024308
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030024308 A1

TITLE: Wheel balancer with a mounting mode of operation

PUBLICATION-DATE: February 6, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Colarelli, Nicholas J. III	Creve Coeur	MO	US	
Douglas, Michael W.	St. Peters	MO	US	
Parker, Paul Daniel	Kirkwood	MO	US	

US-CL-CURRENT: 73/460

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 20. Document ID: US 20030005764 A1

L20: Entry 20 of 40 File: PGPB Jan 9, 2003

PGPUB-DOCUMENT-NUMBER: 20030005764
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030005764 A1

TITLE: Wheel balancer with variation measurement

PUBLICATION-DATE: January 9, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Colarelli, Nicholas J. III	Creve Coeur	MO	US	
Gerdes, Michael D.	St. Peters	MO	US	
Parker, Paul Daniel	Kirkwood	MO	US	

US-CL-CURRENT: 73/462

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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Terms	Documents
L19 and distance	40

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Search Results - Record(s) 11 through 20 of 40 returned.

☐ 11. Document ID: US 20030093188 A1

Using default format because multiple data bases are involved.

L20: Entry 11 of 40 File: PGPB May 15, 2003

PGPUB-DOCUMENT-NUMBER: 20030093188
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030093188 A1

TITLE: Rotation-speed sensor device

PUBLICATION-DATE: May 15, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Morita, Kouichi	Fujisawa-shi		JP	
Sakatani, Ikunori	Fujisawashi		JP	
Endo, Shigeru	Fujisawa-shi		JP	
Miyazaki, Hiroya	Fujisawa-shi		JP	
Sakamoto, Junshi	Fujisawa-shi		JP	
Nakamura, Yuji	Fujisawa-shi		JP	

US-CL-CURRENT: 701/1; 340/438, 701/29, 701/71

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

☐ 12. Document ID: US 20030080857 A1

L20: Entry 12 of 40 File: PGPB May 1, 2003

PGPUB-DOCUMENT-NUMBER: 20030080857
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030080857 A1

TITLE: Process and system for determining the onset of tread rubber separations of a pneumatic tire on a vehicle

PUBLICATION-DATE: May 1, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Hartmann, Bernd	Bad Nenndorf		DE	

Kobe, Andreas	Bensheim	DE

US-CL-CURRENT: 340/425.5; 340/435

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 13. Document ID: US 20030056386 A1

L20: Entry 13 of 40 File: PGPB Mar 27, 2003

PGPUB-DOCUMENT-NUMBER: 20030056386
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030056386 A1

TITLE: Apparatus and method to measure the dimensional and form deviation of crankpins at the place of grinding

PUBLICATION-DATE: March 27, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Danielli, Franco	Zola Predosa		IT	
Dall'Aglio, Carlo	Castello D'Argile		IT	

US-CL-CURRENT: 33/555.1

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 14. Document ID: US 20030055543 A1

L20: Entry 14 of 40 File: PGPB Mar 20, 2003

PGPUB-DOCUMENT-NUMBER: 20030055543
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030055543 A1

TITLE: Robust steerling-pull torque compensation

PUBLICATION-DATE: March 20, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Amberkar, Sanket S.	Ann Arbor	MI	US	
Chandy, Ashok	Fenton	MI	US	
Pattok, Kathryn L.	Saginaw	MI	US	
Colosky, Mark P.	Vassar	MI	US	

US-CL-CURRENT: 701/41; 180/446, 477/1

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

☐ 15. Document ID: US 20030050743 A1

L20: Entry 15 of 40 File: PGPB Mar 13, 2003

PGPUB-DOCUMENT-NUMBER: 20030050743
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030050743 A1

TITLE: Method and system for controlling the behaviour of a vehicle by controlling its tyres

PUBLICATION-DATE: March 13, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Caretta, Renato	Gallarate		IT	
Cesarini, Riccardo	Bergamo		IT	
Mancosu, Federico	Milano		IT	

US-CL-CURRENT: 701/1; 340/442

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 16. Document ID: US 20030036847 A1

L20: Entry 16 of 40 File: PGPB Feb 20, 2003

PGPUB-DOCUMENT-NUMBER: 20030036847
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030036847 A1

TITLE: POSITION AND HEADING ERROR-CORRECTION METHOD AND APPARATUS FOR VEHICLE NAVIGATION SYSTEMS

PUBLICATION-DATE: February 20, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Geier, George J.	Scottsdale	AZ	US	
Figor, Russel S.	Mesa	AZ	US	
Strother, Troy L.	Tempe	AZ	US	

US-CL-CURRENT: 701/209; 701/210

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 17. Document ID: US 20030034884 A1

L20: Entry 17 of 40 File: PGPB Feb 20, 2003

PGPUB-DOCUMENT-NUMBER: 20030034884
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030034884 A1

TITLE: Method and apparatus for detecting decrease in tire air-pressure, and selecting program for thresholds for judging decompression of tire

PUBLICATION-DATE: February 20, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Oshiro, Yuji	Kobe-shi		JP	

US-CL-CURRENT: 340/443

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 18. Document ID: US 20030030774 A1

L20: Entry 18 of 40 File: PGPB Feb 13, 2003

PGPUB-DOCUMENT-NUMBER: 20030030774
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030030774 A1

TITLE: Clinical refractive instruments

PUBLICATION-DATE: February 13, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Raasch, Thomas W.	Upper Arlington	OH	US	

US-CL-CURRENT: 351/205; 351/216

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 19. Document ID: US 20030024308 A1

L20: Entry 19 of 40 File: PGPB Feb 6, 2003

PGPUB-DOCUMENT-NUMBER: 20030024308
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030024308 A1

TITLE: Wheel balancer with a mounting mode of operation

PUBLICATION-DATE: February 6, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Colarelli, Nicholas J. III	Creve Coeur	MO	US	
Douglas, Michael W.	St. Peters	MO	US	
Parker, Paul Daniel	Kirkwood	MO	US	

US-CL-CURRENT: 73/460

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 20. Document ID: US 20030005764 A1

L20: Entry 20 of 40 File: PGPB Jan 9, 2003

PGPUB-DOCUMENT-NUMBER: 20030005764
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030005764 A1

TITLE: Wheel balancer with variation measurement

PUBLICATION-DATE: January 9, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Colarelli, Nicholas J. III	Creve Coeur	MO	US	
Gerdes, Michael D.	St. Peters	MO	US	
Parker, Paul Daniel	Kirkwood	MO	US	

US-CL-CURRENT: 73/462

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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Terms	Documents
L19 and distance	40

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Search Results - Record(s) 11 through 20 of 40 returned.

☐ 11. Document ID: US 20030093188 A1

Using default format because multiple data bases are involved.

L20: Entry 11 of 40 File: PGPB May 15, 2003

PGPUB-DOCUMENT-NUMBER: 20030093188
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030093188 A1

TITLE: Rotation-speed sensor device

PUBLICATION-DATE: May 15, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Morita, Kouichi	Fujisawa-shi		JP	
Sakatani, Ikunori	Fujisawashi		JP	
Endo, Shigeru	Fujisawa-shi		JP	
Miyazaki, Hiroya	Fujisawa-shi		JP	
Sakamoto, Junshi	Fujisawa-shi		JP	
Nakamura, Yuji	Fujisawa-shi		JP	

US-CL-CURRENT: 701/1; 340/438, 701/29, 701/71

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

☐ 12. Document ID: US 20030080857 A1

L20: Entry 12 of 40 File: PGPB May 1, 2003

PGPUB-DOCUMENT-NUMBER: 20030080857
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030080857 A1

TITLE: Process and system for determining the onset of tread rubber separations of a pneumatic tire on a vehicle

PUBLICATION-DATE: May 1, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Hartmann, Bernd	Bad Nenndorf		DE	

Kobe, Andreas	Bensheim	DE

US-CL-CURRENT: 340/425.5; 340/435

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 13. Document ID: US 20030056386 A1

L20: Entry 13 of 40 File: PGPB Mar 27, 2003

PGPUB-DOCUMENT-NUMBER: 20030056386
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030056386 A1

TITLE: Apparatus and method to measure the dimensional and form deviation of crankpins at the place of grinding

PUBLICATION-DATE: March 27, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Danielli, Franco	Zola Predosa		IT	
Dall'Aglio, Carlo	Castello D'Argile		IT	

US-CL-CURRENT: 33/555.1

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 14. Document ID: US 20030055543 A1

L20: Entry 14 of 40 File: PGPB Mar 20, 2003

PGPUB-DOCUMENT-NUMBER: 20030055543
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030055543 A1

TITLE: Robust steerling-pull torque compensation

PUBLICATION-DATE: March 20, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Amberkar, Sanket S.	Ann Arbor	MI	US	
Chandy, Ashok	Fenton	MI	US	
Pattok, Kathryn L.	Saginaw	MI	US	
Colosky, Mark P.	Vassar	MI	US	

US-CL-CURRENT: 701/41; 180/446, 477/1

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

☐ 15. Document ID: US 20030050743 A1

L20: Entry 15 of 40 File: PGPB Mar 13, 2003

PGPUB-DOCUMENT-NUMBER: 20030050743
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030050743 A1

TITLE: Method and system for controlling the behaviour of a vehicle by controlling its tyres

PUBLICATION-DATE: March 13, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Caretta, Renato	Gallarate		IT	
Cesarini, Riccardo	Bergamo		IT	
Mancosu, Federico	Milano		IT	

US-CL-CURRENT: 701/1; 340/442

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

☐ 16. Document ID: US 20030036847 A1

L20: Entry 16 of 40 File: PGPB Feb 20, 2003

PGPUB-DOCUMENT-NUMBER: 20030036847
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030036847 A1

TITLE: POSITION AND HEADING ERROR-CORRECTION METHOD AND APPARATUS FOR VEHICLE NAVIGATION SYSTEMS

PUBLICATION-DATE: February 20, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Geier, George J.	Scottsdale	AZ	US	
Figor, Russel S.	Mesa	AZ	US	
Strother, Troy L.	Tempe	AZ	US	

US-CL-CURRENT: 701/209; 701/210

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

☐ 17. Document ID: US 20030034884 A1

L20: Entry 17 of 40 File: PGPB Feb 20, 2003

PGPUB-DOCUMENT-NUMBER: 20030034884
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030034884 A1

TITLE: Method and apparatus for detecting decrease in tire air-pressure, and selecting program for thresholds for judging decompression of tire

PUBLICATION-DATE: February 20, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Oshiro, Yuji	Kobe-shi		JP	

US-CL-CURRENT: 340/443

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 18. Document ID: US 20030030774 A1

L20: Entry 18 of 40 File: PGPB Feb 13, 2003

PGPUB-DOCUMENT-NUMBER: 20030030774
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030030774 A1

TITLE: Clinical refractive instruments

PUBLICATION-DATE: February 13, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Raasch, Thomas W.	Upper Arlington	OH	US	

US-CL-CURRENT: 351/205; 351/216

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 19. Document ID: US 20030024308 A1

L20: Entry 19 of 40 File: PGPB Feb 6, 2003

PGPUB-DOCUMENT-NUMBER: 20030024308
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030024308 A1

TITLE: Wheel balancer with a mounting mode of operation

PUBLICATION-DATE: February 6, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Colarelli, Nicholas J. III	Creve Coeur	MO	US	
Douglas, Michael W.	St. Peters	MO	US	
Parker, Paul Daniel	Kirkwood	MO	US	

US-CL-CURRENT: 73/460

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 20. Document ID: US 20030005764 A1

L20: Entry 20 of 40 File: PGPB Jan 9, 2003

PGPUB-DOCUMENT-NUMBER: 20030005764
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030005764 A1

TITLE: Wheel balancer with variation measurement

PUBLICATION-DATE: January 9, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Colarelli, Nicholas J. III	Creve Coeur	MO	US	
Gerdes, Michael D.	St. Peters	MO	US	
Parker, Paul Daniel	Kirkwood	MO	US	

US-CL-CURRENT: 73/462

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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L19 and distance	40

Display Format: - Change Format

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Search Results - Record(s) 21 through 30 of 40 returned.

☐ 21. Document ID: US 20020179708 A1

Using default format because multiple data bases are involved.

L20: Entry 21 of 40 File: PGPB Dec 5, 2002

PGPUB-DOCUMENT-NUMBER: 20020179708
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20020179708 A1

TITLE: Automated method of and system for dimensioning objects over a conveyor belt structure by applying contouring tracing, vertice detection, corner point detection, and corner point reduction methods to two-dimensional range data maps of the space above the conveyor belt captured by an amplitude modulated laser scanning beam

PUBLICATION-DATE: December 5, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Zhu, Xiaoxun	Marlton	NJ	US	
Au, Ka Man	Philadelphia	PA	US	
Germaine, Gennady	Cherry Hill	NJ	US	
Good, Timothy A.	Blackwood	NJ	US	
Schnee, Michael	Aston	PA	US	
Scott, Ian	Haddonfield	NJ	US	
Groot, John	San Jose	CA	US	
Wilz, David M. SR.	Sewell	NJ	US	
Rockstein, George B.	Audobon	NJ	US	
Blake, Robert E.	Woodbury Heights	NJ	US	
Dickson, LeRoy	Morgan Hill	CA	US	
Knowles, Carl Harry	Moorestown	NJ	US	

US-CL-CURRENT: 235/454

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

☐ 22. Document ID: US 20020172633 A1

L20: Entry 22 of 40 File: PGPB Nov 21, 2002

PGPUB-DOCUMENT-NUMBER: 20020172633
PGPUB-FILING-TYPE: new

DOCUMENT-IDENTIFIER: US 20020172633 A1

TITLE: Vehicular atmosphere cleansing system

PUBLICATION-DATE: November 21, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Koermer, Gerald S.	Roseland	NJ	US	
Hoke, Jeffrey B.	North Brunswick	NJ	US	
Heck, Ronald M.	Frenchtown	NJ	US	
Poles, Terence C.	Ringoes	NJ	US	
Wolynic, Edward T.	Franklin Lakes	NJ	US	

US-CL-CURRENT: 423/219

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 23. Document ID: US 20020147532 A1

L20: Entry 23 of 40 File: PGPB Oct 10, 2002

PGPUB-DOCUMENT-NUMBER: 20020147532
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20020147532 A1

TITLE: Driving control device and methods for vehicle

PUBLICATION-DATE: October 10, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Inagaki, Shoji	Numazu-shi		JP	
Hattori, Yoshikazu	Aichi-gun		JP	

US-CL-CURRENT: 701/41; 701/91

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 24. Document ID: US 20020134927 A1

L20: Entry 24 of 40 File: PGPB Sep 26, 2002

PGPUB-DOCUMENT-NUMBER: 20020134927
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20020134927 A1

TITLE: Optical encoder

PUBLICATION-DATE: September 26, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Kudo, Koichi	Kanagawa		JP	

US-CL-CURRENT: 250/231.13

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 25. Document ID: US 20020124629 A1

L20: Entry 25 of 40 File: PGPB Sep 12, 2002

PGPUB-DOCUMENT-NUMBER: 20020124629
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20020124629 A1

TITLE: Method and apparatus for continuous monitoring of road surface friction

PUBLICATION-DATE: September 12, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Hurson, James Kevin	Orangeville		CA	

US-CL-CURRENT: 73/9

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 26. Document ID: US 20020116104 A1

L20: Entry 26 of 40 File: PGPB Aug 22, 2002

PGPUB-DOCUMENT-NUMBER: 20020116104
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20020116104 A1

TITLE: Control method for suspension

PUBLICATION-DATE: August 22, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Kawashima, Mitsunori	Wako-shi		JP	
Suto, Shinji	Wako-shi		JP	
Kitazawa, Hirokazu	Wako-shi		JP	
Watanabe, Kazuhisa	Haga-gun		JP	

US-CL-CURRENT: 701/37; 280/5.515

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

27. Document ID: US 20020087251 A1

L20: Entry 27 of 40 File: PGPB Jul 4, 2002

PGPUB-DOCUMENT-NUMBER: 20020087251
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20020087251 A1

TITLE: Road friction coefficients estimating apparatus for vehicle

PUBLICATION-DATE: July 4, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Kogure, Masaru	Tokyo		JP	
Hiwatashi, Yutaka	Tokyo		JP	

US-CL-CURRENT: 701/80; 73/105

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

28. Document ID: US 20020038181 A1

L20: Entry 28 of 40 File: PGPB Mar 28, 2002

PGPUB-DOCUMENT-NUMBER: 20020038181
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20020038181 A1

TITLE: Map displaying method and apparatus, and navigation system having the map displaying apparatus

PUBLICATION-DATE: March 28, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Okude, Mariko	Hitachi-shi		JP	
Endo, Yoshinori	Mito-shi		JP	
Gunji, Yasuhiro	Hitachioota-shi		JP	
Nakamura, Kozo	Hitachioota-shi		JP	

US-CL-CURRENT: 701/208

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

29. Document ID: US 20020014799 A1

L20: Entry 29 of 40 File: PGPB Feb 7, 2002

PGPUB-DOCUMENT-NUMBER: 20020014799
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20020014799 A1

TITLE: Vehicular brake control apparatus and vehicular brake control method

PUBLICATION-DATE: February 7, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Nagae, Akira	Susono-shi		JP	

US-CL-CURRENT: 303/139

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 30. Document ID: US 20010054310 A1

L20: Entry 30 of 40 File: PGPB Dec 27, 2001

PGPUB-DOCUMENT-NUMBER: 20010054310
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20010054310 A1

TITLE: Process for improved determination of the ratio among the radii of the wheels of a vehicle

PUBLICATION-DATE: December 27, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Dieckmann, Thomas	Pattersen		DE	
Michaelsen, Arne	Hannover		DE	

US-CL-CURRENT: 73/146

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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Terms	Documents
L19 and distance	40

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Search Results - Record(s) 31 through 40 of 40 returned.

☐ 31. Document ID: US 20010033106 A1

Using default format because multiple data bases are involved.

L20: Entry 31 of 40 File: PGPB Oct 25, 2001

PGPUB-DOCUMENT-NUMBER: 20010033106
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20010033106 A1

TITLE: Electrically operated braking system having a device for operating electric motor of brake to obtain relationship between motor power and braking torque

PUBLICATION-DATE: October 25, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Shirai, Kenji	Mishima-shi		JP	
Yoshino, Yasunori	Toyota-shi		JP	

US-CL-CURRENT: 303/177

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KMC | Draw De

☐ 32. Document ID: US 20010029419 A1

L20: Entry 32 of 40 File: PGPB Oct 11, 2001

PGPUB-DOCUMENT-NUMBER: 20010029419
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20010029419 A1

TITLE: Road surface friction coefficient estimating apparatus

PUBLICATION-DATE: October 11, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Matsumoto, Shinji	Yokohama-shi		JP	
Kimura, Takeshi	Yokosuka-shi		JP	
Takahama, Taku	Yokosuka-shi		JP	
Toyota, Hiromitsu	Yokosuka-shi		JP	

US-CL-CURRENT: 701/80

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KWIC	Draw De

☐ 33. Document ID: US 20010022585 A1

L20: Entry 33 of 40 File: PGPB Sep 20, 2001

PGPUB-DOCUMENT-NUMBER: 20010022585
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20010022585 A1

TITLE: Bird's-eye view forming method, map display apparatus and navigation system

PUBLICATION-DATE: September 20, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Endo, Yoshinori	Mito-shi		JP	
Fujiwara, Toshio	Hitachi-shi		JP	
Satake, Hiroyuki	Hitachi-shi		JP	
Shojima, Hiroshi	Kashiwa-shi		JP	
Kishi, Norimasa	Yokohama-shi		JP	
Watanabe, Masaki	Yokohama-shi		JP	
Hirano, Motoki	Tokyo		JP	

US-CL-CURRENT: 345/427; 701/25

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KWIC	Draw De

☐ 34. Document ID: US 20010013250 A1

L20: Entry 34 of 40 File: PGPB Aug 16, 2001

PGPUB-DOCUMENT-NUMBER: 20010013250
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20010013250 A1

TITLE: Wheel balancer with speed setting

PUBLICATION-DATE: August 16, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Colarelli, Nicholas J. III	Creve Coeur	MO	US	
Douglas, Michael W.	St. Peters	MO	US	
Parker, Paul Daniel	Kirkwood	MO	US	

US-CL-CURRENT: 73/462; 73/460

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KWIC	Draw De

☐ 35. Document ID: US 20010008985 A1

L20: Entry 35 of 40 File: PGPB Jul 19, 2001

PGPUB-DOCUMENT-NUMBER: 20010008985
PGPUB-FILING-TYPE: new-utility
DOCUMENT-IDENTIFIER: US 20010008985 A1

TITLE: Omnidirectional vehicle and method of controlling the same

PUBLICATION-DATE: July 19, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Wada, Masayoshi	Kanagawa		JP	

US-CL-CURRENT: 701/1; 180/422

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KWIC	Draw De

☐ 36. Document ID: US 20010008086 A1

L20: Entry 36 of 40 File: PGPB Jul 19, 2001

PGPUB-DOCUMENT-NUMBER: 20010008086
PGPUB-FILING-TYPE: new-utility
DOCUMENT-IDENTIFIER: US 20010008086 A1

TITLE: Wheel balancer with control circuit and rim runout measurement

PUBLICATION-DATE: July 19, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Colarelli, Nicholas J. III	Creve Coeur	MO	US	
Douglas, Michael W.	St. Peters	MO	US	
Parker, Paul Daniel	Kirkwood	MO	US	

US-CL-CURRENT: 73/462; 73/460

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KWIC	Draw De

☐ 37. Document ID: US 20010008083 A1

L20: Entry 37 of 40 File: PGPB Jul 19, 2001

PGPUB-DOCUMENT-NUMBER: 20010008083

PGPUB-FILING-TYPE: new-utility
DOCUMENT-IDENTIFIER: US 20010008083 A1

TITLE: Monitoring pneumatic tire conditions

PUBLICATION-DATE: July 19, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Brown, Robert Walter	Medina	OH	US	

US-CL-CURRENT: 73/146

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 38. Document ID: US 20010007209 A1

L20: Entry 38 of 40 File: PGPB Jul 12, 2001

PGPUB-DOCUMENT-NUMBER: 20010007209
PGPUB-FILING-TYPE: new-utility
DOCUMENT-IDENTIFIER: US 20010007209 A1

TITLE: Wheel balancer with control circuit for controlling the application of power to the motor to facilitate mounting

PUBLICATION-DATE: July 12, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Colarelli, Nicholas J. III	Creve Coeur	MO	US	
Douglas, Michael W.	St. Peters	MO	US	
Parker, Paul Daniel	Kirkwood	MO	US	

US-CL-CURRENT: 73/462; 73/460

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 39. Document ID: US 20010007208 A1

L20: Entry 39 of 40 File: PGPB Jul 12, 2001

PGPUB-DOCUMENT-NUMBER: 20010007208
PGPUB-FILING-TYPE: new-utility
DOCUMENT-IDENTIFIER: US 20010007208 A1

TITLE: Wheel balancer for controlling the application of power to the motor and rotation of the wheel/tireassembly

PUBLICATION-DATE: July 12, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Colarelli, Nicholas J. III	Creve Coeur	MO	US	
Douglas, Michael W.	St. Peters	MO	US	
Parker, Paul Daniel	Kirkwood	MO	US	

US-CL-CURRENT: 73/462; 73/460

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 40. Document ID: DE 3717531 A, DE 3717531 C2, US 4855917 A

L20: Entry 40 of 40 File: DWPI Dec 3, 1987

DERWENT-ACC-NO: 1987-343062
DERWENT-WEEK: 198749

TITLE: Anti-blocking vehicle braking system - calculates braking force for each individual wheel to obtain max. slip-free braking effect

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw De

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L13: Entry 2 of 2 File: USPT Mar 19, 2002

US-PAT-NO: 6360165
DOCUMENT-IDENTIFIER: US 6360165 B1

TITLE: Method and apparatus for improving dead reckoning distance calculation in vehicle navigation system

DATE-ISSUED: March 19, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Chowdhary; Mahesh	San Jose	CA		

ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Visteon Technologies, LLC	Dearborn	MI			02

APPL-NO: 09/ 422830 [PALM]
DATE FILED: October 21, 1999

INT-CL: [07] G06 F 7/00

US-CL-ISSUED: 701/205; 701/213
US-CL-CURRENT: 701/205; 701/213

FIELD-OF-SEARCH: 701/200, 701/201, 701/205, 701/206, 701/207, 701/213, 702/85, 702/97, 73/178R, 33/700, 33/772

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

Search Selected Search ALL Clear

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
3845289	October 1974	Franch	
4139889	February 1979	Ingels	
4570227	February 1986	Tachi et al.	
4608656	August 1986	Tanaka et al.	
4611293	September 1986	Hatch et al.	
4672565	June 1987	Kuno et al.	
4673878	June 1987	Tsushima et al.	

☐			
☐	4723218	February 1988	Hasebe et al.
☐	4734863	March 1988	Honey et al.
☐	4751512	June 1988	Longaker
☐	4782447	November 1988	Ueno et al.
☐	4796191	January 1989	Honey et al.
☐	4797841	January 1989	Hatch
☐	4831563	May 1989	Ando et al.
☐	4862398	August 1989	Shimizu et al.
☐	4903212	February 1990	Yokouchi et al.
☐	4914605	April 1990	Loughmiller, Jr. et al.
☐	4918609	April 1990	Yamawaki
☐	4926336	May 1990	Yamada
☐	4937753	June 1990	Yamada
☐	4964052	October 1990	Ohe
☐	4970652	November 1990	Nagashima
☐	4982332	January 1991	Saito et al.
☐	4984168	January 1991	Neukrichner et al.
☐	4989151	January 1991	Nuimura
☐	4992947	February 1991	Nimura et al.
☐	4996645	February 1991	Schneyderberg Van DerZon
☐	4999783	March 1991	Tenmoku et al.
☐	5040122	August 1991	Neukirchner et al.
☐	5046011	September 1991	Kakihara et al.
☐	5060162	October 1991	Ueyama et al.
☐	5067579	November 1991	Kushi et al.
☐	5119301	June 1992	Shimizu et al.
☐	5148884	September 1992	Tsuyama et al.
☐	5177685	January 1993	Davis et al.
☐	5179519	January 1993	Adachi et al.
☐	5220509	June 1993	Takemura et al.
☐	5241478	August 1993	Inoue et al.
☐	5272638	December 1993	Martin et al.
☐	5283743	February 1994	Odagawa
☐	5287297	February 1994	Ihara et al.
☐	5293318	March 1994	Fukushima
☐	5297050	March 1994	Ichimura et al.
	5323152	June 1994	Morita

☐			
☐	5369588	November 1994	Hayami et al.
☐	5374933	December 1994	Kao
☐	5410485	April 1995	Ichikawa
☐	5412573	May 1995	Barnea et al.
☐	5416712	May 1995	Geier et al.
☐	5422639	June 1995	Kobayashi et al.
☐	5434788	July 1995	Seymour et al.
☐	5463554	October 1995	Araki et al.
☐	5486822	January 1996	Tenmoku et al.
☐	5506774	April 1996	Nobe et al.
☐	5513110	April 1996	Fujita et al.
☐	5519619	May 1996	Seda
☐	5521826	May 1996	Matsumoto
☐	5550538	August 1996	Fujii et al.
☐	5862511	January 1999	Croyle et al.
☐	5898390	April 1999	Oshizawa et al.
☐	5912635	June 1999	Oshizawa et al.

FOREIGN PATENT DOCUMENTS

FOREIGN-PAT-NO	PUBN-DATE	COUNTRY	US-CL
0 485 120	May 1992	EP	
0527558	February 1993	EP	
0544403	June 1993	EP	
0 575 943 1	December 1993	EP	
2 271 423	April 1994	GB	
2107985	April 1990	JP	

OTHER PUBLICATIONS

French, MAP matching Origins Approaches and Applications, Rober L. French & Associates, 3815 Lisbon St., Suite 201, Fort Worth, Texas 76107, USA, pp. 91-116.

ART-UNIT: 3661

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ATTY-AGENT-FIRM: Beyer, Weaver & Thomas,LLP

ABSTRACT:

The present invention enables a vehicle navigation system to automatically

compensate for odometer measurement errors due to changes in tire size and/or slip, and to avoid odometer recalibration when slip is present. These capabilities improve the accuracy and reliability of the vehicle navigation system. Slip of a vehicle, e.g., a loss of traction, can occur when a road is wet or covered with snow or ice. It can occur when a road is dry, and a vehicle is accelerating or decelerating rapidly. It can occur rounding a sharp corner. Because an odometer is typically hooked up to a driven wheel, the engine or transmission, there may be large sources of error in the distance estimates derived from the odometer. Utilizing conveniently derived slip signals from an anti-lock brake system (ABS) or from a traction control system (TCS), the slip of the vehicle can be accounted for, even absent a GPS signal to recalibrate the system. This allows for improved accuracy of the system which is particularly noticeable in urban environments where GPS signals may not be available.

12 Claims, 6 Drawing figures

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L13: Entry 2 of 2 File: USPT Mar 19, 2002

DOCUMENT-IDENTIFIER: US 6360165 B1
TITLE: Method and apparatus for improving dead reckoning distance calculation in vehicle navigation system

Detailed Description Text (9):
In the embodiment shown, the distance sensor 314, in this instance an odometer, provides an odometer signal proportionate to the number of rotations of the drive train member (e.g., transmission, drive shaft, or wheel) to which the odometer is coupled. That signal is sampled in sampler 424 and passed to multiplier 402 where it is multiplied by an odometer conversion parameter k1 stored in register 404. The conversion factor converts the odometer signal into an estimated distance traveled. The output of the multiplier, i.e., the odometer derived estimate of distance traveled by the vehicle during the sampling interval, is passed to combiner 432. In the embodiment shown, the ABS and/or traction control module generates a slip signal proportionate to the ratio of the free (non-driven)/driven wheel speed. The slip signal may be generated in analog or digital format and may be subject to sampling in sampler 424. In an embodiment of the invention the slip signal is computed (digitally) on ABS/TCS module and is supplied to navigation systems via Serial Communication Protocol bus (SCP bus) or Intelligent Transportation System data bus (IDB) or Controller Area Network bus (CAN bus). This signal is provided as an input to multiplier 430. The other input to multiplier 430 is the above-discussed odometer derived estimate of distance traveled on signal line 452. The slip corrected odometer output is provided as an input to the combiner 432. The GPS module 320 provides a velocity vector for the vehicle which contains both distance and heading information. The sampled GPS signal is integrated by integrator 406 over the sampling interval to produce a GPS distance and heading estimate to the combiner 432 via, respectively, signal lines 454-456. The geomagnetic sensor or gyro provides a signal corresponding to the heading of the vehicle to the sampler 424. This sampled heading signal is provided via signal line 458 to the combiner 432. In an alternate embodiment of the invention data processing is implemented in analog rather than digital format.

L11: Entry 1 of 2 File: USPT Sep 3, 2002

US-PAT-NO: 6446005
DOCUMENT-IDENTIFIER: US 6446005 B1

TITLE: Magnetic wheel sensor for vehicle navigation system

DATE-ISSUED: September 3, 2002

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PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

Search Selected Search ALL Clear

	PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
☐	4109186	August 1978	Farque	318/587
☐	4480310	October 1984	Alvarez	364/450
☐	4887281	December 1989	Swanson	377/24.1
☐	5600113	February 1997	Ewers	235/95R

☐	5878369	March 1999	Rudow et al.	701/215
☐	5938704	August 1999	Torii	701/23
☐	5944132	August 1999	Davies et al.	180/168
☐	6024655	February 2000	Coffee	473/407

ART-UNIT: 3661

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ABSTRACT:

A system is disclosed for determining precise locations of the golf carts on a golf course in real time as the carts are in use during play of the course. Each cart is outfitted with a dead reckoning navigation (DRN) system for determining speed and direction, and a compass for determining heading of the cart during play. With these parameters and a known origin of the cart to which the DRN system has been calibrated, such as location of a tee box, the location of the cart relative to a known feature of the course such as a cup or hazard may be calculated. The DRN system uses a magnetic wheel sensor assembly having a magnetic strip with spaced alternating opposite magnetic poles affixed to the rim of an inside wheel well or mounting fixture therefor of the cart, mounted to confront a Hall effect sensor. During rotation of the wheel and the strip when the cart is moving, the sensor detects passage of the alternating poles, to measure speed and forward or backward direction of the cart. A compass determines heading of the cart. The DRN system allows operation on courses where GPS-based systems cannot maintain LOS, and is periodically calibrated by a known signal, such as a DGPS signal.

16 Claims, 13 Drawing figures

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L11: Entry 1 of 2 File: USPT Sep 3, 2002

DOCUMENT-IDENTIFIER: US 6446005 B1
TITLE: Magnetic wheel sensor for vehicle navigation system

Abstract Text (1):
A system is disclosed for determining precise locations of the golf carts on a golf course in real time as the carts are in use during play of the course. Each cart is outfitted with a dead reckoning navigation (DRN) system for determining speed and direction, and a compass for determining heading of the cart during play. With these parameters and a known origin of the cart to which the DRN system has been calibrated, such as location of a tee box, the location of the cart relative to a known feature of the course such as a cup or hazard may be calculated. The DRN system uses a magnetic wheel sensor assembly having a magnetic strip with spaced alternating opposite magnetic poles affixed to the rim of an inside wheel well or mounting fixture therefor of the cart, mounted to confront a Hall effect sensor. During rotation of the wheel and the strip when the cart is moving, the sensor detects passage of the alternating poles, to measure speed and forward or backward direction of the cart. A compass determines heading of the cart. The DRN system allows operation on courses where GPS-based systems cannot maintain LOS, and is periodically calibrated by a known signal, such as a DGPS signal.

Application Filing Date (1):
19990813

Brief Summary Text (8):
In co-pending patent application Ser. Nos. 08/423,295 (now U.S. Pat. No. 5,689,431) and 08/525,905, filed Apr. 18, 1995 and Sep. 8, 1995, respectively, assigned to the same assignee as the present application ("The '295 and '905 applications"), improvements are disclosed in golf course positioning and yardage measuring systems utilizing differential GPS (DGPS) (see, for example, Blackwell, "Overview of Differential GPS Methods", Global Positioning System, vol. 3, pp. 89-100, The Institute of Navigation, Washington, D.C. (1986)). With DGPS, errors in distance measuring applications are reduced by broadcasting error correction information from a ground receiver of known location in the vicinity of the user. The difference between a known fixed position of a GPS receiver and its position calculated from the satellite GPS signal fixes the error in the signal, and a continuous correction is provided for all other receivers, fixed or mobile, in the reception area. Knowing the error allows all distance and position calculations at the user's receiver to be corrected.

Brief Summary Text (16):
The ACUTRAK system is golf cart-based, but could be packaged alternatively in smaller vehicles, even a set of golf bag wheels equipped with a mobile unit or a hand-held unit used with a pedometer version of the wheel-tracking system disclosed in the '962 application. That system utilizes virtually all of the features of the PROLINK system disclosed in the '295 and '905 applications, except that the ACUTRAK system places limited reliance on DGPS, using it as a calibration technique only. In its primary functions the ACUTRAK system employs a dead reckoning system that tracks distance moved by and orientation of the wheels, extrapolated to the heading or bearing of the golf cart (or other roving unit) in which a portion of the overall system is incorporated. The ACUTRAK system is unaffected by even frequent

inability to view a satellite navigation system, such as the GPS satellites, requiring only relatively infrequent calibration during play to avoid a gradual increase or buildup of error in measurements as the cart is driven about the course. Thus, instead of experiencing frequent out-of-service indications on the cart monitor, the golfer is cognizant only of continuous, reliable, highly accurate operation of the ACUTRAK system.

Brief Summary Text (17):
The principal features and technology of the ACUTRAK system are not limited to position, distance measurement, navigation, and information on a golf course. Rather, the system may be extended to many other consumer, commercial, and industrial applications of satellite navigation and digital communications technology where problems of GPS or DGPS signal loss can occur whether because of physical obstructions in the vicinity of the roving unit, line of sight problems, or interference from other, stronger signals. Indeed, the ACUTRAK system is usable in virtually any commercial endeavor where it is necessary or desirable to keep track reliably of the accurate position, distance relative to a given point, and/or navigation of a host of roving units, such as in a vehicle fleet management system, package delivery system, or other transportation system, or an agricultural planting and harvesting system, where obstructions or other interference abound.

Brief Summary Text (18):
Also, although the ACUTRAK system is preferably golf cart-based, it could be packaged alternatively or additionally in smaller vehicles, or even in or with a set of golf bag wheels equipped with a mobile unit or a hand-held unit used with a pedometer version of its wheel-tracking system. Any generic terminology used in this application, such as "mobile unit," "portable unit,""roving unit," and the like is intended to apply to any version of the system that utilizes high bandwidth dead reckoning navigation technology which is calibrated by low bandwidth satellite navigation technology. Advantages provided by the synergistic use of these technologies are enhanced by additional features and aspects which are incorporated in hardware and software to provide, for example, fixed distance measurements, in contrast to varying distance measurements resulting from the player's (or more generally, the user's) movement, information communication between base station and roving units, and traffic management.

Brief Summary Text (23):
The requirement of substantially greater communications bandwidth for the DGPS correction information is perhaps the greatest drawback of the method two approach relative to method one. Method one also provides a "cleaner" solution which allows greater flexibility in selecting filtering algorithms to be employed for enhanced performance. Industry standard RTCM-104 was created to encourage and take advantage of the more efficient method one approach. In the disclosure of the '962 application, a floated sensor compass and a single front wheel sensor are used in a preferred embodiment of the DR navigation system of the cart, with the method one DGPS technique used for calibration. The same is true of the present invention, the difference relative to the '962 application residing in the sensor implementation.

Brief Summary Text (24):
Mechanical issues addressed in the implementation of sensors of the ACUTRAK system on a golf cart include (1) selection and mounting of the wheel sensor used for measuring distance traversed by the cart, and (2) selection and mounting of the electronic compass used for measuring bearing (direction, relative to a reference direction, typically true north). It is necessary to determine the most desirable or advantageous wheel for location of the wheel sensor on the golf cart. The rear wheels of the cart undergo slippage during rapid acceleration and braking on wet grass; hence, mounting the sensor on a rear wheel is more likely to result in errors in determination of distance traveled by the cart under those conditions. On the other hand, since the front wheels of the cart can turn, wheel velocity is computed along the direction that the wheel is pointed rather than the direction

the cart frame is pointed. Resulting error may be overcome mathematically in navigation software for the ACUTRAK system, as described in the '962 application.

Brief Summary Text (25):
Selection of a proper sensor for detecting wheel rotation involves several factors. Hall effect sensors detect the presence of magnetic fields and are sufficiently rugged to withstand outdoor extremes of temperature, moisture, and soil contamination, with a limited capability to sense fine movements of the wheel as it rotates, for higher resolution. Optical sensors possess the capability to sense extremely fine movements, but lack robustness in an outdoor environment, and are more expensive than magnetic sensors.

Brief Summary Text (26):
The ACUTRAK system disclosed in the '962 application employs a dead reckoning system that uses a floated compass in conjunction, in one embodiment, with a wheel sensor mounted on one front wheel, with a special acceleration compensation algorithm referred to therein as "compass tilt estimation" algorithm for the floated compass. It is desirable for wheel rotation resolution to be at least 64 counts per wheel revolution, i.e., to possess the capability to detect at least every 5.625 degrees of revolution. A floated compass has a sensor which is floated in a liquid bath and which uses the Earth's gravity to keep the sensor level with respect to the gravity field, thereby resulting in the compass sensor remaining fixed with respect to the earth's magnetic field. In this way, a floated compass allows accurate measurement of magnetic heading under various adverse conditions--for example, when the golf cart is tilted on a hill.

Brief Summary Text (27):
To overcome potential loss of accuracy arising from response of the floated compass to acceleration of the golf cart (e.g., starting, braking, or turning) such that the sensor is artificially tilted throughout an acceleration event, compensation for compass errors that arise during such an event is achieved in the system of the '962 application by high resolution wheel sensing to at least 64 counts per revolution, and an acceleration compensation algorithm run in the navigation computer to predict the effect of the induced tilt on the compass heading output. With a dual front wheel sensor configuration, even greater resolution is required--minimally about 720 counts per revolution (equating to a capability to detect at least every 0.5 degrees of revolution), because mathematical algorithms for such a configuration are highly sensitive to wheel quantization for accurate dead reckoning performance.

Brief Summary Text (28):
In an embodiment of the '962 application system, a wheel sensor constituting a standard optical encoder is employed, with modifications designed for survival of the sensor in the hostile outdoor environment of the golf course. The modifications include encapsulating the case of the sensor in an epoxy compound to seal it against penetration and fouling by water or soil, and using a sealed bearing on the encoder shaft for the same purpose. The wheel sensor has an effective resolution of 1024 counts per revolution, and is projected to be capable of 200 million rotations without failure. In practice, however, "sealed" bearings are something of a misnomer in that they do not filly inhibit fouling in a hostile environment. Hence, the sensor and the accuracy of the system must be subjected to frequent inspection. Servicing or replacement of the wheel sensor must be undertaken in aggravated cases. It would be desirable to provide an improved wheel sensor system, and it is a principal objective of the present invention to do so.

Brief Summary Text (30):
According to the present invention, an ACUTRAK system is implemented in part using a wheel sensor in the form of Hall effect magnetic rotation system. A floated compass is used in conjunction with the wheel sensor for accurate measurement of the rotation and the direction of rotation of the wheel. The sensor element is

attached to a mounting bracket, and a magnetic strip is attached to a mounting frame. The data collected is used to measure distance traveled and cart velocity, as well as detection of vehicle motion, among other things. Unlike other types of wheel sensors, the magnetic wheel sensor is capable of providing rotation measurements in electrically and magnetically noisy environments. This is achieved in part by making the housing for the Hall effect sensors electrically conductive and grounding it to the internal sensor ground. Additionally, the Hall effect sensor assembly is electrically insulated from the chassis of the golf cart. The system generates its data output without any physical interfaces, which effectively eliminates sources of degradation attributable to friction. Moreover, the magnetic wheel sensor can be fully sealed by electrically connecting the sensor integrated circuit (IC) to a printed circuit board, inserting the board into the housing, and then potting the board and the sensor IC assembled thereon completely in place with epoxy, for example, to avoid damage from outside contaminants. Additional advantages of the magnetic wheel sensor are its relative simplicity of assembly, installation, and inspection.

Brief Summary Text (31):
According to the invention, then, apparatus is provided for installation on a golf cart to enable calculation of the distance from the cart to a golf cup, a hazard, or other feature of a hole of a golf course which has been surveyed so that the location of such feature is known, from which to make a close approximation of the distance to such feature from a golf ball in a lie proximate to the cart. The apparatus includes a dead reckoning (DR) wheel sensor arrangement for determining speed and direction (forward/reverse) of the cart relative to a tee box of the hole as a known point of origin to which the DR assembly has been calibrated. The arrangement includes a magnetic strip with a plurality of alternating magnetic poles impressed across the strip, which is attached to the rim of a mounting fixture inside the wheel well of the cart. The Hall effect sensor assembly is affixed to the axle of the wheel for detecting passage of the alternating magnetic poles on the strip during rotation of the wheel. A floated compass is attached to the cart, preferably substantially directly above this wheel, to determine the cart heading. Knowing the parameters of speed, forward/reverse direction, and heading of the cart at any given instant relative to the origin enables calculation of real-time distance from the cart to the known location of a feature of interest of the hole being played with the cart.

Brief Summary Text (33):
A global positioning system receiver of the cart receives differential GPS position signals which are used to re-calibrate the DR wheel sensor assembly at least once during play of each hole to restore a level of accuracy to the calculation of distance by substantially removing error buildup arising since the previous calibration.

Brief Summary Text (34):
Using the invention, a method is provided for performing a relatively accurate calculation of the distance of the ball to a feature of interest on a hole of a golf course which has been surveyed so that the locations of various features on each hole are known. A golf cart on which a dead reckoning navigation (DRN) system is installed (including the magnetic wheel sensor assembly for determining speed and direction of the golf cart and the compass for determining heading of the golf cart during movement thereof and ultimately determining the position of the golf cart) is positioned adjacent a tee box of a hole to be played on the course, as an origin of coordinates for the relative position of the golf cart. After a tee shot, the golf cart is repositioned adjacent the new position of the ball resulting from that shot. As the golf cart is being repositioned, the coordinates of the new position of the ball relative to the origin are determined from the DRN system. Using the new position coordinates in conjunction with the known position coordinates of the cup for the hole being played, the approximate distance from the new position of the ball to the cup is ascertained. At least once during play of a

hole, the DRN system is re-calibrated to restore a level of accuracy of measurements by the DRN system by substantially removing error buildup since the previous calibration of the DRN system from the determinations.

Brief Summary Text (37):
Each of the carts is outfitted with a DRN system of the type embodying the invention, with the magnetic wheel sensor assembly for determining the speed and direction of the cart, and the compass or the like constituting means for calculating the heading of the cart on the course, so as to fix the location of the cart relative to at least one known landmark of the course. The landmark may be any natural or artificial object or feature such as a marker or a tee box, whose location is known, as by course mapping, and to which the DRN system of the cart has been calibrated. In addition to the DRN system, each cart is outfitted with apparatus for wireless communication with the base station, including communication of data derived from calculations employing the DRN system which are indicative of location of the relative to at least the one known landmark. Each cart is also provided with a receiver for receiving differential global positioning system (DGPS) signals from earth satellites in unobstructed line of sight (LOS) to the cart for re-calibration of its DRN system from time to time during each round of play of the course relative to a known landmark, which might typically be the tee box location for the hole being played. In this way, the accuracy of the DRN system of the cart is restored for relatively accurate determination of real-time location of the cart on the course.

Drawing Description Text (5):
FIG. 3 is an exploded perspective view of a preferred embodiment of a wheel sensor assembly for a DR navigation system, according to the present invention;

Drawing Description Text (6):
FIG. 4 is an assembled perspective view of the wheel sensor assembly embodiment of FIG. 3;

Drawing Description Text (10):
FIG. 8 is a block diagram of the preferred embodiment using the magnetic wheel sensor, together with a floated compass;

Detailed Description Text (3):
As is known, "dead reckoning navigation" is initialized with a starting position, velocity, and, in some instances, attitude of the host vehicle, and keeps track of changes in movement, distance and direction of the vehicle from the starting point. The present invention provides an improved wheel rotation sensor as a key component of a cost effective dead reckoning navigation system for use on a golf course. The sensor enables measurement of distance by reference to the number of rotations of the wheel from the starting point, while the direction of travel, which need not and typically would not be a straight line from one point of interest to another, is determined in the horizontal plane by means of an inexpensive compass sensor, for example.

Detailed Description Text (4):
A dead reckoning system can provide information at rates of hundreds of times per second, enable measurement of yardage to a fraction of an inch at any sampling instant, and is not susceptible to masking that would preclude GPS yardage measurements. Dead reckoning systems are limited, however, by sources of error that grow with distance traveled. Using a wheel sensor to measure distance and a compass to measure bearing or heading, as in the present invention, error sources include wheel scale factor (SF), magnetic heading variation error, sensor noise, and wheel spin, as well as potential compass-based errors. For example, tire pressure affects wheel diameter which can produce related error in measurement of distance traveled. It is necessary to provide a capability to estimate errors and to apply corrections so that golf course yardage is measured with accuracy using the dead reckoning

system.

Detailed Description Text (6):
The preferred approach in the DR system for golf course applications uses a single front wheel sensor to measure distance and a floated sensor compass for measuring direction. Only speed and direction in the horizontal plane are needed. Alternatives include use of (i) dual front wheel sensors detecting the wheel rotation for measuring distance, and measuring the difference between the wheel rotations for determining the angular rate; or (ii) a fixed sensor compass for detecting direction, a terrain database for slope locations, and a single front wheel sensor for measuring distance. Dual front wheel sensors are viable but have the disadvantage that turning the front wheels of the cart causes them to be misaligned with the longitudinal axis of the cart Alternative (ii) is also viable, but requires a sophisticated terrain database to determine the severity of the slope at any particular location on the golf course.

Detailed Description Text (9):
In conjunction with the preferred embodiment of a wheel sensor mounted on one front wheel, the floated compass employs a compass tilt estimation algorithm described in detail in the '962 application. The floated compass uses a sensor floated in a liquid bath so that the sensor remains fixed with respect to the earth's gravity and magnetic field, whereby to enable accurate measurement of heading even when the golf cart is tilted on a hill. It is desirable that wheel rotation resolution be at least 64 counts per wheel revolution, to detect at least every 5.625 degrees of revolution. The floated compass sensor is artificially tilted during cart acceleration in starting, braking, or turning, producing errors which are compensated by (i) the high resolution wheel sensing and (ii) the compass tilt estimation algorithm.

Detailed Description Text (10):
Dual front wheel sensors require greater resolution, on the order of minimum resolution of 720 counts per revolution which equates to detection of every 0.5 degrees of revolution. This is because the mathematical algorithms for a dual front wheel application are extremely sensitive to wheel quantization for accurate dead reckoning performance.

Detailed Description Text (11):
In a preferred embodiment of a wheel sensor assembly 24 of the present invention, shown in exploded view in FIG. 3 and in assembled view in FIG. 4, the magnetic wheel rotation system includes a sensor 25, a sensor mounting bracket 26, a magnetic strip 28, and a magnet mounting fixture 29. As further shown in the more detailed sectioned side view of FIG. 5A, the sensor 25 includes a dual element Hall effect sensor device 30, which, in the preferred embodiment is a Hall effect speed/direction sensor (e.g., part number A3421, available from Allegro Microsystems, Inc. of Worcester, Mass.). The Hall effect sensor device 30 is soldered to a printed wiring board or printed circuit board (PCB) 32, and the PCB with attached sensor is then inserted into a metallic (electrically conductive) cylindrical housing or cylinder 31 (see, also, FIG. 5B). As shown in FIG. 5A, also provided are a grounding lug 33 from a short wire 34 associated with a four conductor shielded cable 35 (FIG. 5C), a connector 36, and connector pins 37, for purposes to be described presently.

Detailed Description Text (13):
With continued reference to FIG. 5A, short wire 34 and grounding lug 33 crimped thereto are fastened to housing cylinder 31 by a corrosive-resistant screw 41, to assure that the cylinder shares the same electrical ground with the Hall effect sensors 38, 39. The use of an electrically conductive housing which is grounded in this manner serves to shield the device against electrical and magnetic noise present in the environment in which the housing is located, and which would otherwise preclude proper operation and functioning of the Hall effect sensor. The

PCB 32 is dimensioned and configured to slide into the metal cylinder 31 so as to position the attached sensor device a minimum distance d (typically, 0.020 inch) from one end of the cylinder, facing the magnetic strip 28 (FIGS. 3 and 4) when the wheel sensor assembly is fully assembled on a front wheel of the cart. This configuration helps to maximize the performance of the magnetic wheel rotation system of wheel sensor assembly 24.

Detailed Description Text (14):
After insertion of the PCB 32 with sensor device 30 mounted thereon, but before assembly onto a mounting bracket and connection of grounding lug 33, the metal cylinder 31 is filled with suitable benign potting compound (such as epoxy). This filler serves both to prevent sensor 30 from moving (relative to each of metallic cylinder 31 and external magnetic strip 28), and to serve as a barrier against contamination or fouling as a consequence of the hostile environment of the golf course. The hostility of the course to the DR system of the cart exists from presence of soil, fertilizer, water, mud, debris, and the like which can be churned up onto the wheel hub 43 (FIGS. 3 and 4) and into the wheel well 44 of the wheel 45 on which the wheel sensor assembly 24 is mounted, and onto the wheel sensor assembly 24 itself, as the cart is driven about the course. When the potting compound has cured, the exposed ends of the wire conductors at the opposite end of the four conductor cable 35 are terminated with male connector pins 37 which are then inserted into female connector terminals in the connector body 36.

Detailed Description Text (17):
Strip 28 is magnetized with north and south poles arranged in an alternating pattern (for example, alternating poles every 1/4 inch for the exemplary length dimension noted above) as viewed from the surface of the magnetic strip confronting an end of Hall effect sensor device 30 when the unit is assembled onto a front wheel of the golf cart. All of the alternating poles are of the same width. Ideally, the magnetic strip has a length such that an integer number of north-south pole pairs is present when it is installed onto the magnet mounting fixture 29. In practice, however, the magnetic strip length--such as that in the above example--may be slightly longer to compensate for contraction of the magnetic material during assembly (90-1/2 poles, rather than 90 poles, in the latter example). This slight additional length will degrade the instantaneous accuracy of the wheel rotation sensor system to a virtually negligible extent. Since there is no contact between elements of sensor device 30 and magnetic strip 28 during relative movement therebetween when the golf cart is in use, the sensor system itself will not suffer degradation or wear as a result of any frictional force, which is a distinct advantage.

Detailed Description Text (18):
The magnet mounting fixture 29 is a somewhat bowl-shaped piece of material intended to mate with the inner portion of the wheel hub 43 and with mounting holes that mate with mounting holes of the hub, so that fixture 29 will accept the wheel mounting lugs or bolts of the vehicle. It is essential that the magnet mounting fixture mounting holes be precisely sized and aligned with those of the vehicle wheel mounting lugs to minimize any variation in the spacing between magnetic strip 28 and sensor device 30 during relative rotation of the two after installation of the wheel sensor assembly on the cart. The magnet mounting fixture is specially constructed to allow the magnetic strip 29 to be attached to its internal surface at the rim portion of the fixture, without the presence of protuberances or unevenness of any other kind. The adhesive used to attach the magnetic strip to the magnet mounting fixture, while not confined to the exemplary Loctite material referred to above, should be selected to avoid any adverse effect from materials or temperatures likely to encountered by the cart during normal use.

Detailed Description Text (19):
The longitudinal position of the sensor device 30 within mounting bracket 26 is determined by use of a manufacturing fixture which is specific to the geometry of

the wheel assembly of the golf cart on which the sensor bracket is to be mounted. In this way, the high tolerance alignment or adjustment is accomplished during the manufacturing/assembly process, rather than during installation in the less hospitable environs of the golf course, which also results in a substantial saving of time in the installation process.

Detailed Description Text (20):
It is important to observe that as a result of the design provided by the present invention, the lateral alignment of the sensor to the magnetic strip is not crucial. In practice, the wheel sensor assembly bracket is readily attached to the cart, and the wheel is then bolted on in the usual manner, with little or no need for any further adjustment. As noted earlier herein, while either front wheel may be selected as the one with which the assembly is to cooperate, the left front wheel is preferred, taking into account factors such as the location and added weight of the driver of the cart, the location of the antenna for the GPS system to be used for periodic or sporadic calibration of the DR navigation system, and the proximity to fixed sources of potential electrical or magnetic interference on the cart. As a practical matter, the magnetic wheel sensor assembly 24 is installed on a fully assembled cart by removing the designated front wheel 45 from the hub of the cart 50. Once the wheel is removed, the sensor mounting bracket 26 is readily attached to the front axle 51 (or other suitable fixed part of the structure of the vehicle), so as to finally maintain the relative positions of the sensor device 30 and magnetic strip 28 to permit rotation of the latter about the former when the installation of the entire wheel sensor assembly 24 is completed.

Detailed Description Text (21):
By way of example, as illustrated in FIGS. 3, 4, and 6, the magnet mounting fixture 29 of wheel sensor assembly 24 resides in the wheel hub 43 of the front wheel 45 (e.g., on the left, or driver's, side) from its position on the front axle 51 of the golf cart 50. Mounting bracket 26 is slidably positioned along and above front axle 51 with an adjustable collar clamp 52 about its lower leg for rotational alignment of sensor device 30 with magnetic strip 28, i.e., so that the upper end of the Hall effect sensor device is aligned to directly confront the magnetic strip 28 at all times during rotation of the latter about the former, albeit that the two are maintained at all times in precise spaced-apart relation by the longitudinal alignment of the sensor device. The cable 35 is then routed such that it will not bind or be pinched by any portion of the structure, either while the cart is moving or at a standstill. To that end, as well as to prevent excessive stress or strain on the wire conductor connections of cable 35 to PCB 32 potted within cylinder 31, the cable may be secured to the mounting bracket 26 by a tie-down clamp 58 (FIG. 5). The magnet mounting fixture 29 is slid over the wheel mounting lugs for reinstallation of wheel 45. Upon proper rotational alignment of the sensor device 30 relative to the magnetic strip, the attachment bolts 54 (which have been inserted through respective mating holes in axle bearing mounting flange 56, magnet mounting fixture 29 and wheel hub 43 during the assembly process) are secured by final tightening of nuts 55 thereon, and the collar clamp 52 is tightened to secure the mounting bracket in place in the final assembly. Mounting of the Hall effect sensor device 30 above the axle 51 is preferred because in this location the axle keeps the sensor sheltered from water, mud, soil, rocks, grass, fertilizer, twigs, branches, and other debris that might be encountered as the cart is driven along the course during play. The location of the sensor device 30 inside the wheel well 44 at the rim thereof further protects the sensor. Of course, debris is much less a problem where the cart is used on courses having a "cart path only" rule for driving the golf cart.

Detailed Description Text (22):
The final assembly of the wheel sensor assembly 24 onto left front wheel 45 of cart 50 is shown most clearly in FIG. 4, with additional reference to FIG. 6.

Detailed Description Text (23):

The electrical isolation of electrically conductive sensor housing cylinder 31 from mounting bracket 26 prevents conducted electrical noise from being transmitted to the very sensitive Hall effect sensors in element 30 mounted on PCB 32 and potted within the cylinder. This is critical to achieving reliable and accurate magnetic measurements on a vehicle propelled by a pulse width modulated DC electric motor, as is the case with an electric golf cart. Large magnetic and electric fields are produced by such a motor, and shielding is imperative for the magnetic sensor approach of the present invention.

Detailed Description Text (24):
It will be observed from the foregoing description, that the wheel sensor assembly system is relatively simple and inexpensive to produce. Moreover, the system installation on the golf cart or other vehicle is also a relatively easy task, which is important to allow a fleet of golf carts to be readily implemented with the capabilities of the ACUTRAK system, and to be readily serviced for replacement of parts if and when the need arises.

Detailed Description Text (25):
The Hall effect sensor device 30 is supplied with power through the sensor cable 35 by means of a power wire and a ground wire among the four conductors. One of the remaining two conductor wires of cable 35 provides an output signal from the sensor device indicative of speed, the speed signal being composed of digital output pulses whose number is proportional to the number of magnetic poles on magnetic strip 28 that pass by the Hall effect sensor device 30 during rotation of the wheel as the cart is driven along the course. The remaining conductor wire of cable 35 provides an output signal from the sensor device indicative of direction (forward movement or backward movement of the cart) as described earlier herein. An alternate approach is to send the outputs of the two Hall effect sensors through these two wires directly to the DRN computer for quadrature decoding.

Detailed Description Text (27):
The depiction of cart 50 in FIG. 6 also illustrates the location of magnetic wheel sensor assembly 24 at the inner wheel well and axle of left front wheel 45. The floated compass and its assembly, preferably mounted in the present embodiment in the roof assembly of the cart at 107 substantially directly above the location of the sensor assembly 24, are fully described in the '962 application, which is duplicated in pertinent part here for the sake of convenience and clarity to the reader. A preferred floated compass sensor is Model No. C-80 manufactured by KVH Industries of Middletown, R.I., to provide measurements of the magnetic heading accurate to one degree. The compass sensor is preferably mounted inside the system roof assembly on the left (driver) front side of the golf cart so that the compass is virtually directly above the top of the left front wheel of the cart. This mounting location minimizes lever arm effects between the wheel sensor and the compass, especially with acceleration compensation. The compass should be located as remotely as possible from any ferrous metal on the cart, to avoid distortion of the magnetic field and the direction of true north, which would degrade the accuracy of the compass readings.

Detailed Description Text (28):
FIGS. 7A and 7B are top and side views of an exemplary compass assembly, illustrating one technique for assembling the compass onto a bracket 60 to be mounted in the roof assembly of the golf cart. The compass bracket 60 is composed of aluminum (avoiding the use of a ferrous metal) configured as a plate which is bent to maintain the compass sensor 61 in a generally level position when the roof assembly with bracket 60 mounted therein is installed on the golf cart. The compass mounts to the bracket over a small circular hole that accommodates a protruding magnetic sensor on the compass circuit card. As noted above, the compass sensor is maintained at a horizontal level orientation when the vehicle is on a grade, but cannot differentiate vehicle acceleration forces from gravitational forces so that vehicle turns, acceleration, and braking will cause the compass to tilt out of the

horizontal plane and introduce heading errors. The '962 application fully describes the calculation of a compass tilt estimate of the effect of acceleration on a floated compass sensor to induce tilt, and its effect on the compass heading output, from data obtained from the compass and the wheel sensor, which will not be duplicated here. This estimate is used to compensate for tilt errors.

Detailed Description Text (29):
A floated compass/front wheel sensor system using the magnetic wheel sensor of the present invention is shown in block diagrammatic form in FIG. 8. The DR sensors are the floated magnetic compass 63 and magnetic wheel sensor 64. The outputs of both sensors (.psi..sub.m for 63 and a pulse stream and level indicative of wheel speed and direction for 64) are delivered to DR navigation algorithms section 65 following initial processing. Output .psi..sub.m is subjected to low pass filtering at 66, and the filtered information derived from the compass sensor output is applied, together with a factor .omega..sub.m related to rate of change of heading derived at 67 from the filtered output and a factor Z.sup.-1 which is an inverse of the residual measurement, a factor .beta..sub.i representing the Earth's magnetic inclination, and inputs derived in similar fashion from the processed output of magnetic wheel sensor 64, relating to wheel speed V.sup.w and wheel acceleration .alpha., to develop a compass tilt estimate correction factor .DELTA..psi. at 68. This correction factor is then applied at 69 to the processed output from the compass sensor 63 to compensate for tilt error.

Detailed Description Text (30):
The resulting data is applied to a compass correction table at 71 and is also added to a factor .beta..sub.d representing the Earth's magnetic declination at 70. The compass correction table (a lookup table) also receives an input of compass corrections from a DGPS/DR calibration which utilizes the differential GPS calibration to restore the accuracy of the dead reckoning navigation system. The table 71 correction .delta..psi..sub.1 is added to the output of 70 at 72 and the result is applied to a table calculator 74 along with information derived from the magnetic wheel sensor output processing path.

Detailed Description Text (31):
In the latter path, the output of magnetic wheel sensor 64 is subjected to application of a wheel scale factor error correction Sf.sub.w from the DGPS/DR calibration at 75, to compensate an error that increases with distance traveled over time. The resulting output undergoes processing similar to that provided in the compass sensor path, as described above, so that the pair of outputs related to wheel speed and acceleration are obtained and applied to develop the compass tilt estimation at 68, while the wheel speed factor is also applied to provide steering compensation at 76. Also applied to the latter are the turn rate (rate of change of heading) factor .omega..sub.m and a factor representing the wheel base of the cart, from which speed (velocity) compensation factors V.sub.x and V.sub.y are derived for application to table calculator 74.

Detailed Description Text (33):
Acceleration in the golf cart 50 is computed as described in the '962 application. The accuracy of the acceleration computation is limited by the resolution and noise of the magnetic wheel sensor and heading sensor. The turn rate estimate is particularly affected by systemic errors in the compass output caused by sensor tilt and other uncompensated hard/soft iron (i.e., ferrous metal) effects.

Detailed Description Text (34):
FIG. 9 is a simplified top view of golf cart 50 showing the front wheels 45 (left) and 80 (right) angled in a turn and the various angles and dimensions used in calculations. Steering compensation is achieved as follows. The left front wheel is being used for speed determination, and the direction of the front wheels is not aligned with the body frame of cart 50 in a turn. Turned front wheels induce velocity in both the vehicle x and y axes. The steering angle .alpha. is determined

from the wheel speed, turn rate, and wheel base. For compass correction, true heading of the vehicle must be computed by the magnetic heading from the compass. Magnetic heading is corrected for the Earth magnetic field declination (.beta..sub.d) and for mounting errors on the vehicle and residual hard/soft iron (ferrous material) errors. These mounting and ferrous material errors are estimated by DGPS/DR calibration, essentially by comparing the estimated true heading to the ground track angle computed from DGPS measurement data. A correction to the compass correction table (a lookup table indexed by magnetic heading) is computed based on this heading residual. The error in the table at the current magnetic heading is applied to the magnetic heading to form a corrected true heading.

Current US Cross Reference Classification (7):
701/213

CLAIMS:

1. A system for determining the precise locations of a plurality of golf carts on a golf course in real time as the golf carts are in use during play of the golf course, comprising: a base station including apparatus for wireless communication with each of said carts; each of said carts having a DC electric motor propulsion system, and each of said carts being outfitted with a dead reckoning navigation (DRN) system and a heading detector to fix the location of the respective cart relative to at least one known feature of the golf course to which the respective DRN system has been calibrated; each said DRN system including a magnetic wheel sensor assembly constructed and adapted for detecting speed and forward-backward direction of the cart and for inhibiting electrical and magnetic fields arising from said motor propulsion system and from other sources external to said magnetic wheel sensor assembly from interference with operation of said magnetic wheel sensor assembly; each of said carts further including apparatus for wireless communication with said base station including communication of data derived from said DPN system and said heading detector indicative of location of the respective cart relative to said at least one known feature; and each of said carts having a receiver for receiving differential global positioning system DGPS) signals from earth satellites for re-calibration of the DRN system thereof to said at least one known feature from time to time during each round of play of the golf course, whereby to restore the accuracy of the DRN system upon each re-calibration for relatively accurate determination of real-time location of the respective cart on said golf course.

2. The location determining system of claim 1, wherein said heading detector comprises a floated compass positioned substantially directly above said magnetic wheel sensor assembly on the respective golf cart.

4. The location determining system of claim 1, wherein said magnetic sensor assembly comprises a Hall effect sensor and a magnet, wherein said Hall effect sensor is fixed relative to a wheel of the respective golf cart and said magnet is coupled to said wheel for rotation about said Hall effect sensor as said wheel rotates during driving of said golf cart.

8. The location determining system of claim 4, wherein said magnet comprises a magnetic strip with multiple alternating magnetic poles thereon, and said magnetic strip is affixed to a wheel well of said wheel or mounting fixture thereof for passage of said alternating magnetic poles adjacent to said Hall effect sensor as said wheel and said magnetic strip thereon rotates during driving of the respective golf cart about said golf course.

9. The location determining system of claim 8, wherein said Hall effect sensor is positioned to confront said magnetic strip in spaced-apart relation thereto to detect the number of alternating magnetic poles passing by said Hall effect sensor and the direction thereof as said magnetic strip rotates on said wheel during

driving of said golf cart.

10. The location determining system of claim 9, wherein said Hall effect sensor is mounted on an axle of said golf cart on which said wheel rotates.

13. Apparatus for installation on a golf cart to calculate the distance from the cart to a golf cup, a hazard, or other feature of a hole of a golf course which has been surveyed so that the location of said golf cup, hazard, or other feature on said hole is known, to enable close approximation of the distance thereto from the lie of a golf ball proximate said cart, said golf cart having access to GPS transmissions solely for calibration of a dead reckoning (DR) navigation system installed on the cart, said apparatus comprising: a DR wheel sensor assembly for determining speed and direction of said cart relative to a known point of origin of said hole, said assembly including a magnetic strip having a plurality of alternating magnetic poles impressed longitudinally thereon for attachment to a cylindrical wall of a wheel or mounting fixture therefor of said golf cart, and a Hall effect sensor for detecting said alternating magnetic poles during rotation of said wheel when attached in a fixed location on said golf cart in confronting relation to said magnetic strip, to measure speed and forward-backward direction of the golf cart, and further including an electrically conductive housing for said sensor adapted for electrical insulation from the chassis of the golf cart, said housing connected to the sensor to share the same electrical ground therewith, so as to inhibit electrical and magnetic interference with operation of the sensor from the propulsion system of the golf cart or from other sources of electrical or magnetic field.

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L13: Entry 1 of 2 File: USPT Sep 3, 2002

DOCUMENT-IDENTIFIER: US 6446005 B1
TITLE: Magnetic wheel sensor for vehicle navigation system

Brief Summary Text (25):
Selection of a proper sensor for detecting wheel rotation involves several factors. Hall effect sensors detect the presence of magnetic fields and are sufficiently rugged to withstand outdoor extremes of temperature, moisture, and soil contamination, with a limited capability to sense fine movements of the wheel as it rotates, for higher resolution. Optical sensors possess the capability to sense extremely fine movements, but lack robustness in an outdoor environment, and are more expensive than magnetic sensors.

Detailed Description Text (9):
In conjunction with the preferred embodiment of a wheel sensor mounted on one front wheel, the floated compass employs a compass tilt estimation algorithm described in detail in the '962 application. The floated compass uses a sensor floated in a liquid bath so that the sensor remains fixed with respect to the earth's gravity and magnetic field, whereby to enable accurate measurement of heading even when the golf cart is tilted on a hill. It is desirable that wheel rotation resolution be at least 64 counts per wheel revolution, to detect at least every 5.625 degrees of revolution. The floated compass sensor is artificially tilted during cart acceleration in starting, braking, or turning, producing errors which are compensated by (i) the high resolution wheel sensing and (ii) the compass tilt estimation algorithm.

Detailed Description Text (20):
It is important to observe that as a result of the design provided by the present invention, the lateral alignment of the sensor to the magnetic strip is not crucial. In practice, the wheel sensor assembly bracket is readily attached to the cart, and the wheel is then bolted on in the usual manner, with little or no need for any further adjustment. As noted earlier herein, while either front wheel may be selected as the one with which the assembly is to cooperate, the left front wheel is preferred, taking into account factors such as the location and added weight of the driver of the cart, the location of the antenna for the GPS system to be used for periodic or sporadic calibration of the DR navigation system, and the oximity to fixed sources of potential electrical or magnetic interference on the . As a practical matter, the magnetic wheel sensor assembly 24 is installed on ly assembled cart by removing the designated front wheel 45 from the hub of t 50. Once the wheel is removed, the sensor mounting bracket 26 is readily to the front axle 51 (or other suitable fixed part of the structure of the o as to finally maintain the relative positions of the sensor device 30 strip 28 to permit rotation of the latter about the former when the f the entire wheel sensor assembly 24 is completed.

WEST Search History

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DATE: Monday, November 22, 2004

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		DB=PGPB,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR	
☐	L20	L19 and distance	40
☐	L19	L18 and (rotat$ same (error$ or coefficien$ or factor$))	64
☐	L18	L17 and (wheel$ with (siz$ or dimension$ or circum$))	158
☐	L17	=20031126	13098
		DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR	
☐	L16	L15 and (wheel$ with (siz$ or dimension$ or circum$))	10
☐	L15	L14 and distance	109
☐	L14	L7 and (rotat$ same (error$ or coefficien$ or factor$))	139
☐	L13	L12 and (rotat$ same (error$ or coefficien$ or factor$))	2
☐	L12	6360165.pn. or 6446005.pn.	2
☐	L11	L10 and (wheel$ with (siz$ or demension$))	2
☐	L10	L9 and (wheel$ with sens$)	23
☐	L9	L8 and (distance same ((turn$ or rotat$) with wheel$))	30
☐	L8	l1 and L7	307
☐	L7	701/19,20,201,205,213.ccls.	1931
☐	L6	L5 and distance	28
☐	L5	L4 and ((turn$ or rotat$) with wheel$)	29
☐	L4	L3 and (wheel$ with sens$)	50
☐	L3	l1 and L2	239
☐	L2	701/19,20.201,205,213.ccls.	1471
☐	L1	=20031126	20196

END OF SEARCH HISTORY

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☐ 1. Document ID: US 6701228 B2

L16: Entry 1 of 10 File: USPT Mar 2, 2004

US-PAT-NO: 6701228
DOCUMENT-IDENTIFIER: US 6701228 B2

TITLE: Method and system for compensating for wheel wear on a train

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw. D

☐ 2. Document ID: US 6611755 B1

L16: Entry 2 of 10 File: USPT Aug 26, 2003

US-PAT-NO: 6611755
DOCUMENT-IDENTIFIER: US 6611755 B1
**** See image for Certificate of Correction ****

TITLE: Vehicle tracking, communication and fleet management system

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw. D

☐ 3. Document ID: US 6446005 B1

L16: Entry 3 of 10 File: USPT Sep 3, 2002

US-PAT-NO: 6446005
DOCUMENT-IDENTIFIER: US 6446005 B1

TITLE: Magnetic wheel sensor for vehicle navigation system

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw. D

☑ 4. Document ID: US 6401036 B1

L16: Entry 4 of 10 File: USPT Jun 4, 2002

US-PAT-NO: 6401036
DOCUMENT-IDENTIFIER: US 6401036 B1

TITLE: Heading and position error-correction method and apparatus for vehicle navigation systems

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw. De

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☐ 5. Document ID: US 6360165 B1

L16: Entry 5 of 10 File: USPT Mar 19, 2002

US-PAT-NO: 6360165
DOCUMENT-IDENTIFIER: US 6360165 B1

TITLE: Method and apparatus for improving dead reckoning distance calculation in vehicle navigation system

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw. De

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☐ 6. Document ID: US 6243657 B1

L16: Entry 6 of 10 File: USPT Jun 5, 2001

US-PAT-NO: 6243657
DOCUMENT-IDENTIFIER: US 6243657 B1
**** See image for Certificate of Correction ****

TITLE: Method and apparatus for determining location of characteristics of a pipeline

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw. De

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☐ 7. Document ID: US 6148269 A

L16: Entry 7 of 10 File: USPT Nov 14, 2000

US-PAT-NO: 6148269
DOCUMENT-IDENTIFIER: US 6148269 A

TITLE: Wheel diameter calibration system for vehicle slip/slide control

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	KWIC	Draw. De

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☐ 8. Document ID: US 5155684 A

L16: Entry 8 of 10 File: USPT Oct 13, 1992

US-PAT-NO: 5155684
DOCUMENT-IDENTIFIER: US 5155684 A

TITLE: Guiding an unmanned vehicle by reference to overhead features

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

☐ 9. Document ID: US 4819168 A

L16: Entry 9 of 10 File: USPT Apr 4, 1989

US-PAT-NO: 4819168
DOCUMENT-IDENTIFIER: US 4819168 A

TITLE: Train control having improved wheel wear adjustment for more accurate train operation

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

☐ 10. Document ID: US 4709194 A

L16: Entry 10 of 10 File: USPT Nov 24, 1987

US-PAT-NO: 4709194
DOCUMENT-IDENTIFIER: US 4709194 A

TITLE: Method of controlling the mode of driving electric vehicles

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

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Terms	Documents
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L16: Entry 4 of 10 File: USPT Jun 4, 2002

DOCUMENT-IDENTIFIER: US 6401036 B1
TITLE: Heading and position error-correction method and apparatus for vehicle navigation systems

Brief Summary Text (5):
Numerous automotive navigational systems have been developed in recent years for such applications as providing real-time driving directions and providing emergency services for automobiles. These navigational systems typically include a satellite-based positioning system or a "dead reckoning system" (DRS), or a combination of the two. In a dead reckoning system, the heading and position of a vehicle are determined using sensors such as gyroscopes and odometers. Typically, automobile navigational and positioning systems use a DRS having an interface between a transmission odometer (for tracking speed and distance) and a gyroscope (to track the vehicle's heading). Dead reckoning systems are often used in tandem with a satellite-based navigational system such as a Global Positioning System ("GPS").

Brief Summary Text (12):
In the case of the commonly used vibrational gyroscope, a vibrating beam is used to determine heading changes. Over time, the vibrational characteristics of the beam change and these changes result in changes in the measured angular rate, even when there is no rotation of the beam, thus producing the gyroscope bias drift. Significantly, bias drift produces a position error that grows quadratically with distance traveled for a vehicle moving at a constant speed. For example, a bias of only 0.055 deg/sec produces a position error of 5% of distance traveled, or 50 meters, after 1 kilometer of travel and 25% of distance traveled, or 1.25 kilometers, after 5 kilometers of travel. While the position error can be compensated for using GPS under conditions where a minimum of four satellites are in view of the vehicle, the error cannot be effectively compensated for during periods of GPS outage such as occur in tunnels or dense foliage environments. It is therefore desirable to have methods for correcting heading and position errors in dead reckoning systems resulting from gyroscope bias and gyroscope bias drift.

Detailed Description Text (8):
FIG. 1 illustrates a particularly preferred embodiment of a navigational system 2 for a vehicle 4 comprising a heading sensor 6, a distance-traveled sensor 8, a reference vehicle position system 10, a DRS 12 that receives heading and position data from the heading sensor 6, the distance-traveled sensor 8, and the reference vehicle position system 10, and an application specific device ("ASD") 14 that receives heading and position data from the DRS 12. The inventive methods provided herein, however, may be used with any vehicle navigational system 2 having a DRS and do not require that navigational system 2 include a reference vehicle position system 10 or an ASD 14.

Detailed Description Text (10):
Distance-traveled sensor 8 is preferably an odometer 18; however, the invention is not limited to such an embodiment. There are two fundamental types of odometers 18 known to those in the art: reluctance sensors, which use passive magnetic flux change to measure velocity, and Hall effect sensors, which are active and detect wheel rotations. The preferred system and method will work with any pre-installed odometer 18 in vehicle 4; however, the invention preferably uses a reluctance

sensor-based odometer. Odometer 18 output is typically in units of pulse counts when a Hall effect sensor is used. Each pulse in the pulse count refers to a specific amount of wheel rotation, preferably 1/24th to 1/48th of the circumference of a tire. Those of skill in the art will recognize that alternative velocity or distance-traveled sensors, including but not limited to Doppler radar installed underneath vehicle 4 or one or more lateral accelerometers, would be equally useful in the invention.

Detailed Description Text (12):
DRS 12 preferably comprises an analog-to-digital converter ("A/D converter") 27, a DR processor 28, a heading sensor interface 30, a distance-traveled sensor interface 32, an ASD interface 33, and a memory 34. DRS processor 28 preferably comprises a bias drift rate filter 38, a heading filter 42, and a position filter 44, as illustrated in FIG. 2B. Preferably DRS 12 receives heading change data from heading sensor 6 via heading sensor interface 30 and distance-traveled data from the distance-traveled sensor 8 via distance-traveled sensor interface 32. The heading change data from heading sensor 6 and the distance-traveled data from the distance-traveled sensor 8 are converted from analog to digital signals in the A/D converter 27, and transmitted to the DR processor 28. When vehicle navigational system 2 includes a reference position system 10, DRS 12 also receives reference heading and position data from reference position system 10. In embodiments where reference position system 10 is a GPS system, the DRS 12 also receives reference heading and position data from GPS receiver 22.

Detailed Description Text (13):
DRS 12 converts the heading sensor output to a heading change in units of degrees or radians and the distance-traveled sensor 18 output to units of meters. DRS 12 then integrates GPS heading and position data with heading and position data received from heading sensor 6 and distance-traveled sensor 8 to determine the current heading and position of vehicle 4. DR processor 28 also transmits the integrated heading and position data to ASD 14 via ASD interface 33. In a preferred embodiment, DRS 12 is preferably integrated into GPS receiver 22. In such embodiments, GPS receiver 22 preferably further comprises an analog-to-digital converter for converting the output of heading sensor 6 and distance-traveled sensor 8 to digital signals.

Detailed Description Text (19):
The initial step 100 of a preferred method is transmitting heading data from heading sensor 6 (.DELTA.H.sub.s) and position data from distance-traveled sensor 8 (P.sub.s) to DRS 12, via heading sensor interface 30 and distance-traveled sensor interface 32, respectively. DR processor 28 then converts the data received from analog data (.DELTA.H.sub.s, P.sub.s) to digital data (.DELTA.H.sub.D, P.sub.D) having units usable by the correction method. Conversion of the data from an analog to a digital signal results in a quantization error, which is accounted for in the heading sensor bias update procedure, as discussed below.

Detailed Description Text (21):
If the vehicle is stationary, a second computational means updates the heading sensor bias (b). Preferably, the second computational means is a heading sensor bias filter 34 (hereinafter "bias filter 34"), as shown in step 110. As input, bias filter 34 receives the heading sensor reading while the vehicle is stationary (.DELTA.H.sub.D (t.sub.k)). Bias filter 34 is preferably a simple, fixed gain filter; a variable gain, low pass filter; or a Kalman filter. Most preferably, heading sensor bias filter 34 is a Kalman filter, as the Kalman filter can appropriately model both the quantization error associated with the analog to digital conversion of heading sensor and distance-traveled sensor data and the expected stability of the bias from past measurements.

Detailed Description Text (51):
Once the heading has been updated, the position is updated. In DR position

propagation step 145, a forward estimate of position is calculated using the heading data corrected by the heading filter 42 and distance-traveled data calculated by DR processor 28 based on odometer output. The distance traveled east (.DELTA.p.sub.e) is calculated by multiplying the total distance traveled (.DELTA.d.sub.D) by the sine of the average heading is the distance moved east, while distance traveled north (.DELTA.p.sub.n) is calculated by multiplying the total distance traveled by the cosine of average heading, as shown in Equations 9-10 is the distance moved north.

Detailed Description Text (69):
To demonstrate the effectiveness of the real-time implementation of the invention, sample test data is presented in FIGS. 5 and 6. The data was collected using a Toyota Camry with an integrated GPS/DR system as a test vehicle using a Motorola 8 channel ONCORE receiver and DR system test board, including the low cost gyro, and interface to the vehicle's odometer, and a microprocessor with built-in A/D converter. The system included a Murata gyroscope and an interface to the vehicle's odometer. The invention was tested while the vehicle traveled due north. The GPS antenna was disconnected for 3 kilometers of travel. As shown in FIG. 5, significant cross-track error equaling approximately 3.7% of the distance traveled developed without a correction mechanism in place.

Detailed Description Text (71):
The delayed real-time solution depicted in FIG. 5, together with the derived heading and gyroscope bias estimates, was compensated off-line using the present invention. FIG. 6 displays the resulting compensated positional error. Using the compensation routine of the invention, cross-track position error was reduced to 0.3% of distance traveled.

Current US Cross Reference Classification (16):
701/213

CLAIMS:

1. A vehicle navigational system having built-in error correction comprising:

(a) a distance traveled sensor;

(b) a heading sensor having a bias that drifts over time;

(c) a dead reckoning system having a distance traveled sensor interface and a heading sensor interface, wherein the dead reckoning component receives distance-traveled data from the distance-traveled sensor and heading data from the heading sensor and generates a first set of vehicle position data and a first set of vehicle heading data;

(d) a reference vehicle position system in direct communication with the dead reckoning component, wherein the reference vehicle position system generates a second set of vehicle heading data and a second set of vehicle position data to the dead reckoning system;

(e) a first computational means for determining if the vehicle is stationary;

(f) a second computational means for generating an updated heading sensor bias;

(g) a third computational means for generating a heading sensor bias drift rate;

(h) a fourth computational means for integrating the first set of vehicle heading data and the second set of vehicle heading data into an integrated vehicle heading;

(i) a fifth computational means for integrating the first set of vehicle position data and the second set of vehicle position into an integrated vehicle heading;

(j) a sixth computational means for calculating an integrated vehicle heading correction using the estimated bias drift rate to compensate for integrated vehicle heading errors induced by heading sensor bias drift and an integrated vehicle position correction using the first integrated vehicle heading correction to compensate for integrated vehicle position errors induced by heading sensor bias drift; and

(k) a seventh computational means for calculating a corrected vehicle heading and position.

5. The apparatus of claim 1 wherein the distance-traveled sensor is an odometer.

6. The apparatus of claim 1 wherein the dead reckoning system comprises a dead reckoning processor, a heading sensor interface, and a distance-traveled sensor interface.

8. The apparatus of claim 6 wherein the distance-traveled sensor interface is an odometer interface.

21. A method for correcting heading and position error induced by a sensor drift in a vehicle navigational system, comprising the steps of:

(a) transmitting heading data from a heading sensor to a dead reckoning system having a memory and storing the heading data in a memory of the dead reckoning system;

(b) transmitting distance traveled data from a distance-traveled sensor to the dead reckoning system and storing the distance traveled data in the memory of the dead reckoning system;

(c) transmitting heading sensor bias data from the heading sensor to the dead reckoning system and storing the heading sensor bias data in the memory of the dead reckoning component;

(d) transmitting reference position data from a satellite to the reference vehicle position system;

(e) calculating a heading sensor bias drift rate using the data transmitted to the dead reckoning system and stored in the memory of the dead reckoning system;

(f) estimating a vehicle heading using the heading data transmitted to the dead reckoning system and stored in the memory of the dead reckoning system;

(g) estimating a vehicle position using the distance traveled data transmitted to the dead reckoning system and stored in the memory of the dead reckoning system and the estimated vehicle heading;

(h) calculating an integrated vehicle heading using the estimated vehicle heading and the reference position data transmitted to the reference vehicle position system;

(i) determining whether the integrated vehicle heading requires correction;

(j) calculating an integrated vehicle position using the estimated vehicle position and the position data transmitted to the reference vehicle position system;

(k) determining whether the integrated vehicle position requires correction;

(l) calculating a heading correction using the calculated heading sensor bias drift rate;

(m) calculating a position correction using the calculated heading correction;

(n) correcting the vehicle heading using the calculated heading correction; and

(o) correcting the vehicle position using the calculated position correction.

35. The method of claim 21 wherein the distance-traveled sensor is an odometer.

36. The method of claim 21 wherein the dead reckoning system comprises a dead reckoning processor, a heading sensor interface, and a distance-traveled sensor interface.

38. The apparatus of claim 36 wherein the distance-traveled sensor interface is an odometer interface.

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☐ 1. Document ID: US 6701228 B2
L16: Entry 1 of 10 File: USPT Mar 2, 2004

US-PAT-NO: 6701228
DOCUMENT-IDENTIFIER: US 6701228 B2

TITLE: Method and system for compensating for wheel wear on a train

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

☐ 2. Document ID: US 6611755 B1
L16: Entry 2 of 10 File: USPT Aug 26, 2003

US-PAT-NO: 6611755
DOCUMENT-IDENTIFIER: US 6611755 B1
**** See image for Certificate of Correction ****

TITLE: Vehicle tracking, communication and fleet management system

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

☐ 3. Document ID: US 6446005 B1
L16: Entry 3 of 10 File: USPT Sep 3, 2002

US-PAT-NO: 6446005
DOCUMENT-IDENTIFIER: US 6446005 B1

TITLE: Magnetic wheel sensor for vehicle navigation system

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

☐ 4. Document ID: US 6401036 B1
X(b) L16: Entry 4 of 10 File: USPT Jun 4, 2002

US-PAT-NO: 6401036
DOCUMENT-IDENTIFIER: US 6401036 B1

TITLE: Heading and position error-correction method and apparatus for vehicle navigation systems

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

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☐ 5. Document ID: US 6360165 B1

L16: Entry 5 of 10 File: USPT Mar 19, 2002

US-PAT-NO: 6360165
DOCUMENT-IDENTIFIER: US 6360165 B1

TITLE: Method and apparatus for improving dead reckoning distance calculation in vehicle navigation system

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

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☐ 6. Document ID: US 6243657 B1

L16: Entry 6 of 10 File: USPT Jun 5, 2001

US-PAT-NO: 6243657
DOCUMENT-IDENTIFIER: US 6243657 B1
**** See image for Certificate of Correction ****

TITLE: Method and apparatus for determining location of characteristics of a pipeline

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

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☐ 7. Document ID: US 6148269 A

L16: Entry 7 of 10 File: USPT Nov 14, 2000

US-PAT-NO: 6148269
DOCUMENT-IDENTIFIER: US 6148269 A

TITLE: Wheel diameter calibration system for vehicle slip/slide control

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

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☐ 8. Document ID: US 5155684 A

L16: Entry 8 of 10 File: USPT Oct 13, 1992

US-PAT-NO: 5155684
DOCUMENT-IDENTIFIER: US 5155684 A

TITLE: Guiding an unmanned vehicle by reference to overhead features

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw De

☐ 9. Document ID: US 4819168 A

L16: Entry 9 of 10 File: USPT Apr 4, 1989

US-PAT-NO: 4819168
DOCUMENT-IDENTIFIER: US 4819168 A

TITLE: Train control having improved wheel wear adjustment for more accurate train operation

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw De

☐ 10. Document ID: US 4709194 A

L16: Entry 10 of 10 File: USPT Nov 24, 1987

US-PAT-NO: 4709194
DOCUMENT-IDENTIFIER: US 4709194 A

TITLE: Method of controlling the mode of driving electric vehicles

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw De

Clear | Generate Collection | Print | Fwd Refs | Bkwd Refs | Generate OACS

Terms	Documents
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10/721227

L16: Entry 4 of 10 File: USPT Jun 4, 2002

US-PAT-NO: 6401036
DOCUMENT-IDENTIFIER: US 6401036 B1

TITLE: Heading and position error-correction method and apparatus for vehicle navigation systems

DATE-ISSUED: June 4, 2002

INVENTOR-INFORMATION:

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APPL-NO: 09/ 678598 [PALM]
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US-CL-CURRENT: 701/214; 180/167, 180/168, 340/436, 340/500, 340/903, 340/988, 342/107, 342/163, 342/357.02, 342/357.08, 342/357.14, 342/359, 342/457, 701/200, 701/207, 701/213, 701/216, 701/217, 701/220, 701/221, 701/224, 701/26, 702/150, 702/92, 702/93, 702/96, 702/99

FIELD-OF-SEARCH: 701/214, 701/16, 701/213, 701/207, 701/23, 701/300, 701/217, 701/220, 701/216, 701/224, 701/221, 701/26, 701/208, 701/25, 701/200, 701/41, 701/3, 701/301, 702/150, 702/93, 702/92, 702/96, 702/99, 342/357.14, 342/457, 342/357.08, 342/359, 342/357.02, 342/31, 342/357.03, 342/456, 342/107, 342/163, 340/500, 340/436, 340/995, 340/988, 340/435, 340/903, 375/148, 375/150, 180/167, 180/168, 246/122R, 246/121

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

Search Selected Search ALL Clear

	PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
☐	5075693	December 1991	McMillan et al.	342/457
☐	5297028	March 1994	Ishikawa	364/571.03
☐	5319561	June 1994	Matsuzaki	364/454
☐	5339246	August 1994	Kao	364/457
☐	5680313	October 1997	Whitaker et al.	364/460
☐	5784029	July 1998	Geier	342/357
☐	5986547	November 1999	Korver et al.	340/500
☐	6029111	February 2000	Croyle	701/207
☐	6055477	April 2000	McBurney et al.	701/207
☐	6091359	July 2000	Geier	342/357.14
☐	6240367	May 2001	Lin	701/214
☐	6243657	June 2001	Tuck et al.	702/150
☐	6249542	June 2001	Kohli et al.	375/150

ART-UNIT: 3661

PRIMARY-EXAMINER: Cuchlinski, Jr.; William A.

ASSISTANT-EXAMINER: Mancho; Ronnie

ATTY-AGENT-FIRM: King; John

ABSTRACT:

The present invention provides methods and devices that enable correction of gyroscope bias and gyroscope bias drift in low-cost, vehicular navigation and positioning systems without using estimates of position and heading, and subsequent correction of heading and position errors resulting from gyroscope bias and bias drift, without relying on assumptions regarding gyroscope bias or predetermined time-dependent gyroscope bias drift profiles. The invention improves over existing GPS/DR systems that do not compensate for actual gyroscope bias instability, but instead correct the heading and position error that is induced by the bias instability and then correct estimates of gyroscope bias based on the corrected position and heading. The inventive methods provided herein can be used with any DR vehicle positioning system that uses a gyroscope.

51 Claims, 7 Drawing figures

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L16: Entry 5 of 10 File: USPT Mar 19, 2002

DOCUMENT-IDENTIFIER: US 6360165 B1
TITLE: Method and apparatus for improving dead reckoning distance calculation in vehicle navigation system

Abstract Text (1):
The present invention enables a vehicle navigation system to automatically compensate for odometer measurement errors due to changes in tire size and/or slip, and to avoid odometer recalibration when slip is present. These capabilities improve the accuracy and reliability of the vehicle navigation system. Slip of a vehicle, e.g., a loss of traction, can occur when a road is wet or covered with snow or ice. It can occur when a road is dry, and a vehicle is accelerating or decelerating rapidly. It can occur rounding a sharp corner. Because an odometer is typically hooked up to a driven wheel, the engine or transmission, there may be large sources of error in the distance estimates derived from the odometer. Utilizing conveniently derived slip signals from an anti-lock brake system (ABS) or from a traction control system (TCS), the slip of the vehicle can be accounted for, even absent a GPS signal to recalibrate the system. This allows for improved accuracy of the system which is particularly noticeable in urban environments where GPS signals may not be available.

Brief Summary Text (6):
Prior systems use a road network stored in a map database to calculate current vehicle positions. These systems send distance and heading information derived from either GPS or dead reckoning to perform map matching. Map matching calculates the current position based on the road network stored in the database and the input position and heading data. These systems also use map matching to calibrate sensors. The map matching, however, has inaccuracies due to map errors as well as inherent inaccuracies resulting from the fact that map matching must look back in time and match data to a location. As such, map matching can only calibrate the sensors or serve as a position determining means when an absolute position is identified on the map. However, on a long, straight stretch of highway, sensor calibration or position determination using map matching may not occur for a significant period of time.

Brief Summary Text (8):
The accuracy of data received from a vehicle's odometer is influenced by a number of factors, including wheel size and pulse rate. An odometer typically detects wheel revolutions as representative of traveled distance, the tire size is directly related to the accuracy of the reported travel distance. For current navigation Systems, once the vehicle's tire size is known, it can be manually programmed into the navigation system to properly correlate wheel revolutions to traveled distance. However, it is well known that the size of a vehicle's tires change over time as they wear down from contact with the road. Moreover, factors such as the air pressure of the tires and the weight loaded on the vehicle at any given time produce variation in travel distances reported by the odometer. The tire size may be periodically reprogrammed into the system to account for such variations, but this is obviously impractical in that a difficult manual reprogramming would frequently be required, possibly every time the navigation system is used.

Brief Summary Text (9):

Another potential source of error in measured distance reported by an odometer is a mismatch between the odometer's pulse rate and the pulse rate setting of the navigation system. Odometers generate a pulse train in which a specific number of pulses (e.g., 2000) represent a unit distance (e.g., a mile). For example, Nissan vehicles employ a pulse rate of 2000 pulses/mile while Ford vehicles employ a pulse rate of 8000 pulses/mile. Therefore, each navigation system must be configured to correspond to the type of vehicle in which it is installed, otherwise very large-scale errors may result. If, for example, the pulse rate setting in a navigation system installed in a Ford corresponded to the pulse rate of a Nissan, an error factor of four would be introduced. The pulse rate setting is typically done before a navigation system is installed and is difficult to change where, for example, the odometer in the vehicle is changed, or the navigation system is installed in a different vehicle. Thus, while detection of the error may be elementary, correction of the error remains problematic.

Brief Summary Text (10):
U.S. Pat. No. 5,898,390 entitled "Method and Apparatus for Calibration of a Distance Sensor in a Vehicle Navigation System" discloses a method and apparatus for modifying an odometer reading to compensate for odometer errors resulting from pulse rate and tire size. The method and apparatus provides for correction of a first distance estimate derived from the odometer reading with a second distance estimate, typically produced by an external navigation system, i.e., GPS. Additionally, the pulse rate setting may be adjusted so as to reduce deviations between the first and second distance estimates. If pulse rate settings and tire size were the only significant sources of odometer error, the teachings of the '390 patent would allow the production of a reliable navigation system. However, there are other far more significant sources of odometer error which the '390 patent fails to account for, as will be discussed shortly. This failing is particularly critical in urban environments where scattering objects, such as buildings, reduce the possibility of frequent GPS initiated recalibration of the odometer based distance estimates. Absent these recalibrations, the other far more significant sources of odometer error will result in unacceptable cumulative errors in the odometer distance estimate during intervals in which GPS recalibration is not possible.

Brief Summary Text (11):
What is needed, therefore, is a method and apparatus for removing error from an odometer distance estimate in a vehicle navigation system.

Brief Summary Text (13):
The present invention enables a vehicle navigation system to automatically compensate for odometer measurement errors due to changes in tire size and/or slip, and to avoid odometer recalibration when slip is present. These capabilities improve the accuracy and reliability of the vehicle navigation system. Slip of a vehicle, e.g., a loss of traction, can occur when a road is wet or covered with snow or ice. It can occur when a road is dry and a vehicle is accelerating or decelerating rapidly. It can also occur rounding a sharp corner. Because an odometer is typically hooked up to a driven wheel, the engine or transmission, there may be large sources of error in the distance estimates derived from the odometer. Utilizing conveniently derived slip signals from an anti-lock brake system (ABS) or from a traction control system (TCS), the slip of the vehicle can be accounted for, even absent a GPS signal to recalibrate the system. This allows for improved accuracy of the system, which is particularly noticeable in urban environments where GPS signals may not be available.

Brief Summary Text (14):
In an embodiment of the invention, an apparatus for correcting odometer error in a vehicle is disclosed. The apparatus includes an odometer, a slip sensor and a first and second logic. The odometer generates an odometer indication signal indicative of a distance traveled by the vehicle. The slip sensor generates a slip indication

signal indicative of a slip of the vehicle. The first logic couples to the slip sensor and the odometer to combine the slip indication signal and the odometer indication signal with a conversion parameter to form an odometer distance estimate. The second logic adjusts the odometer distance estimate with values representative of the slip indication signal to form an adjusted odometer distance estimate corresponding to the distance traveled by the vehicle during the first time interval.

Brief Summary Text (15):
In an embodiment of the invention, a vehicle navigation system is disclosed. The navigation system includes: an odometer, a slip sensor, a heading sensor, a radio navigation sensor, and a first and second logic. The odometer generates an odometer indication signal indicative of a distance traveled by the vehicle. The slip sensor generates a slip indication signal indicative of a slip of the vehicle. The heading sensor generates a heading indication signal indicative of the heading of the vehicle. The first logic converts the odometer indication signal to a first distance estimate utilizing an odometer conversion parameter. Additionally, the first logic determines a position of the vehicle based on a known prior position, the first distance estimate and the heading of the vehicle, indications of which are obtained from said heading sensor. The radio navigation sensor receives radio navigation signals. The second logic converts the radio navigation signals to an external distance estimate for the vehicle and determines whether the external distance estimate includes indicia of reliability. If the external distance estimate includes indicia of reliability, the odometer conversion parameter utilized by the first logic is adjusted.

Brief Summary Text (16):
In another embodiment of the invention, a method for determining distance traveled by a vehicle is disclosed. The method comprises the acts of:

Brief Summary Text (18):
combining a value representative of the odometer indication signal with a conversion parameter to form an odometer distance estimate; and

Brief Summary Text (19):
adjusting the odometer distance estimate with values representative of the slip indication signal to form an adjusted odometer distance estimate corresponding to the distance traveled by the vehicle during the first time interval.

Brief Summary Text (21):
obtaining during a first time interval an odometer indication signal indicative of a distance traveled by the vehicle, a slip indication signal indicative of the slip of the vehicle, and a heading indication signal indicative of the heading of the vehicle;

Brief Summary Text (22):
converting the odometer indication signal to a first distance estimate;

Brief Summary Text (23):
determining a position of the vehicle based on a known prior position, the first distance estimate obtained during said act of converting, and the heading of the vehicle, indications of which are obtained during said first act of obtaining;

Brief Summary Text (24):
obtaining during the first time interval an external distance estimate for the vehicle from a radio navigation system;

Brief Summary Text (25):
determining whether the external distance estimate includes indicia of reliability; and

Brief Summary Text (26):
adjusting an odometer conversion parameter utilized in said act of converting if the external distance estimate includes indicia of reliability as determined in said second act of determining.

Drawing Description Text (4):
FIG. 2 is a graph showing actual and sensed distances utilized to iteratively calculate vehicle position according to the current invention.

Drawing Description Text (7):
FIGS. 5-6 are process flow diagrams showing distance estimation and recalibration portions of a vehicle navigation system, in accordance with an embodiment of the current invention.

Detailed Description Text (2):
The present invention enables a vehicle navigation system to automatically compensate for odometer measurement errors due to changes in tire size and/or slip, and to avoid odometer recalibration when slip is present. These capabilities improve the accuracy and reliability of the vehicle navigation system. Slip of a vehicle, e.g., a loss of traction, can occur when a road is wet or covered with snow or ice. It can occur when a road is dry, and a vehicle is accelerating or decelerating rapidly. It can also occur rounding a sharp corner. Because an odometer is typically hooked up to a driven wheel, the engine or transmission, there may be large sources of error in the distance estimates derived from the odometer. Utilizing conveniently derived slip signals from an anti-lock brake system (ABS) or from a traction control system (TCS), the slip of the vehicle can be accounted for, even absent a GPS signal to recalibrate the system. This allows for improved accuracy of the system, which is particularly noticeable in urban environments where GPS signals may not be available.

Detailed Description Text (3):
FIG. 1 shows a top-plan view of an automobile 100. The automobile has front wheels 110-112 and rear wheels 120-122. The automobile includes a vehicle navigation module 132 and a traction control system (TCS) and/or an anti-lock brake system (ABS) module 134. The TCS/ABS module utilizes information received from front and rear wheel sensors 114-116, 124-126, respectively, to control the acceleration and deceleration of the vehicle in a manner which minimizes slip. Slip may occur under any road conditions: wet/dry, inclined/level, and snow/ice. Acceleration or deceleration of the vehicle may induce slip. ABS and TCS work generally to control deviations in the rotational rate of driven and non-driven wheels. During the course of regulating vehicle behavior, the TCS/ABS modules generate a slip signal. The slip signal corresponds to the relative rotational rates of driven and non-driven wheels. The signal may include a number of parameters, e.g., average front wheel speed, average rear wheel speed, etc. This signal from the TCS/ABS module or an alternate source provides an input to the navigation module 132. The navigation module also receives input from a distance sensor 130. In the embodiment shown, the distance sensor is an odometer. The odometer is typically coupled to the drive train at the engine, transmission, differential, or wheels.

Detailed Description Text (4):
FIG. 2 is a graph showing the iterative process by which vehicle navigation is accomplished. The graph shows the successive approximations of vehicle position x.sub.0 -x.sub.4 at times t.sub.0 -t.sub.4. Linear motion of the vehicle along the X axis is assumed for the sake of simplicity. As will be obvious to those skilled in the art, a complete navigation system will provide similar iterative processes for estimating vehicle heading. Starting from an initial position x.sub.0, successive estimates x.sub.0 -x.sub.4 of vehicle position are made at times t.sub.0 -t.sub.4 using estimates of distance traveled .DELTA.D.sub.1 -.DELTA.D.sub.4 in each of the time intervals t.sub.0 -t.sub.1, t.sub.1 -t.sub.2, t.sub.2 -t.sub.3,

t.sub.3 -t.sub.4. In any interval, preferably independent, multiple estimates of both the distances traveled and heading changes of the vehicle over the sampling interval are obtained. These may be derived from sources such as dead reckoning sensors (e.g., gyros, accelerometers) and GPS, for example. Other radio navigation systems than GPS may be utilized, including ground or satellite based signal sources. Each sensor contains errors both fixed and variable. In the example shown in FIG. 2, the vehicle position at time t.sub.3 is x.sub.3. There are several varying estimates 220 and 224 from, respectively, a GPS system and an odometer of the actual distance 222 traveled .DELTA.D.sub.a4 over the time interval t.sub.3 - t.sub.4. The GPS estimate .DELTA.D.sub.g4 falls short of the actual distance traveled. The odometer estimate .DELTA.D.sub.o4 exceeds the actual distance traveled. There are two sources of odometer error over the sampling interval. Slip or tire size can cause under/over estimates of distance traveled from the odometer. In the example shown, slip and tire size both contribute to an overestimate, respectively, 226-228 of distance traveled from the odometer. In any given sampling interval, some estimates may be more reliable than others. The vehicle navigation system of the current invention uses a slip signal to improve the dead reckoning distance estimate from the odometer, as well as to avoid recalibration of the odometer (See FIGS. 4-5) when slip exceeds acceptable levels. By improving the accuracy of the primary distance-measuring device, e.g., the odometer, the overall accuracy of the navigation system of which it is a part is improved.

Detailed Description Text (5):
FIG. 3 is a hardware block diagram of the components of a hybrid embodiment of the vehicular navigation system. The anti-lock brake system (ABS) 310 and the traction control system (TCS) 312 are shown coupled to the hybrid navigation system 132. The hybrid navigation system contains dead reckoning sensors 314-318, a distance sensor, a geomagnetic sensor or gyro, and a reverse gear sensor. In an embodiment of the invention, the distance sensor is an odometer coupled to one of: the engine, the transmission, the drive train, or the wheels of the vehicle. The geomagnetic sensor is a compass which measures the compass heading of the vehicle and forms a sensor signal corresponding thereto. Additionally, a GPS module 320 is shown. All of the sensors are coupled via an interface 330 to the system bus 350. CPU 332, RAM 334, ROM 336, main memory 328, and the I/O interface 338 are also shown coupled to the system bus. The output communicator 342 and the user interface 344 are shown coupled to the I/O interface 338.

Detailed Description Text (8):
FIG. 4 is a software/hardware block diagram showing a detailed embodiment of the hybrid GPS/dead reckoning module 400 with logic for correcting odometer error, including error due to slip. The logic/processes disclosed herein may be implemented on the hardware discussed above in connection with FIG. 3. The hybrid GPS/dead reckoning module accepts input from dead reckoning sensors including distance sensor 314, reverse gear 318 and geomagnetic sensor or gyro 316. The hybrid module also accepts inputs from other sources including GPS module 320, ABS 310, and TCS 312. The output of the dead reckoning/inertial-guidance module 400 provides an input to the optional map matching logic/processes 434 (See FIG. 6) which, in turn, provide the updated distance and heading information 440 for the system/user. The dead reckoning and inertial guidance module 400 includes a multiplier 402, a register 404, an integrator 406, a calibration unit 408, a sampler 424, a multiplier 430, and a combiner 432. The calibration unit 408 includes a slip comparator 410, a slip threshold register 412, a GPS comparator 414, a GPS threshold register 416, a divider 418 and a switch 420.

Detailed Description Text (9):
In the embodiment shown, the distance sensor 314, in this instance an odometer, provides an odometer signal proportionate to the number of rotations of the drive train member (e.g., transmission, drive shaft, or wheel) to which the odometer is coupled. That signal is sampled in sampler 424 and passed to multiplier 402 where it is multiplied by an odometer conversion parameter k1 stored in register 404. The

conversion factor converts the odometer signal into an estimated distance traveled. The output of the multiplier, i.e., the odometer derived estimate of distance traveled by the vehicle during the sampling interval, is passed to combiner 432. In the embodiment shown, the ABS and/or traction control module generates a slip signal proportionate to the ratio of the free (non-driven)/driven wheel speed. The slip signal may be generated in analog or digital format and may be subject to sampling in sampler 424. In an embodiment of the invention the slip signal is computed (digitally) on ABS/TCS module and is supplied to navigation systems via Serial Communication Protocol bus (SCP bus) or Intelligent Transportation System data bus (IDB) or Controller Area Network bus (CAN bus). This signal is provided as an input to multiplier 430. The other input to multiplier 430 is the above-discussed odometer derived estimate of distance traveled on signal line 452. The slip corrected odometer output is provided as an input to the combiner 432. The GPS module 320 provides a velocity vector for the vehicle which contains both distance and heading information. The sampled GPS signal is integrated by integrator 406 over the sampling interval to produce a GPS distance and heading estimate to the combiner 432 via, respectively, signal lines 454-456. The geomagnetic sensor or gyro provides a signal corresponding to the heading of the vehicle to the sampler 424. This sampled heading signal is provided via signal line 458 to the combiner 432. In an alternate embodiment of the invention data processing is implemented in analog rather than digital format.

Detailed Description Text (10):
The combiner thus receives multiple independent estimates of distance on signal lines 450-454 and of heading on signal lines 456-458. The combiner iteratively provides updated estimates of changes in the vehicle's distance and heading, utilizing the most reliable of the input signals or combinations thereof These are provided to the map matching module 434. The processes implemented in the combiner for producing updated estimates of distance traveled by the vehicle are set forth in the following FIG. 5.

Detailed Description Text (11):
Up to this point, the operation of the calibration unit 408 has not been discussed. That unit provides input to the register 404, which results in the modification of the odometer conversion parameter. Odometer derived distance estimates are sensitive to minor changes in the magnitude of the odometer conversion parameter. For this reason, it is necessary that the conversion parameter only be modified under controlled conditions. Those controlled conditions include a reliable alternative distance estimate which occurs during an interval in which slip of the vehicle is below an acceptable threshold. This objective is achieved by the logic shown within estimator 408. The slip and GPS comparators 410-412 compare the slip and GPS distance values to corresponding slip and GPS thresholds stored in registers 412-416, respectively. A GPS distance estimate may be deemed reliable if the velocity vector from which it is derived exceeds a threshold value, e.g., 1.5 m/s. Below this value, artificially induced and random fluctuations in the GPS velocity vector make distance estimates derived therefrom inaccurate. A slip signal should, conversely, lie below a threshold level in order for a correction to the odometer conversion parameter to be warranted. If, for example, the vehicle is on ice or accelerating rapidly, a correction to the odometer conversion factor would be inappropriate, since the odometer signal itself contains a large slip related error which may be intermittent in nature.

Detailed Description Text (12):
When slip is below a slip threshold, and the GPS velocity/distance above a GPS threshold, the outputs of both comparators will be positive, thereby closing switch 420 and coupling the output of divider 418 directly to register 404. This provides feedback from signal lines 452-454 which serves to equilibrate the odometer derived distance estimate with the GPS derived distance estimate.

Detailed Description Text (13):

Thus, the conversion parameter is adjusted only during intervals in which confidence in the adjustment of the parameter is high. This increases the reliability of the odometer derived distance estimate during subsequent intervals in which either the GPS is unreliable or slip is unacceptably high.

Detailed Description Text (15):
FIGS. 5-6 are process flow diagrams showing the details of the iterative processing associated with distance and heading estimation and distance recalibration in a vehicle navigation system, in accordance with an embodiment of the current invention. Processing begins at start block 500 and proceeds to decision process 502. In decision process 502, a determination is made as to whether the TCS/ABS and whether the dead reckoning sensors, e.g., odometer, slip and heading, are operational. If they are operational, control is passed to process 504. In process 504, all registers are initialized so that a new update to the vehicle's position and heading may be made. Control then passes in parallel to process blocks 510-516. Process 510 handles the obtaining of a GPS signal, e.g., a velocity vector(s). Process 512 handles the obtaining of a dead reckoning distance signal, e.g., odometer pulses. Process 514 handles the obtaining of a dead reckoning slip signal from, for example, an ABS or TCS system onboard the vehicle. Process 516 handles the obtaining of a dead reckoning heading signal from, for example, gyro, an electronic compass. Control then passes to decision process 520. In decision process 520, a determination is made as to whether the time for this particular evaluation interval has elapsed. If it has not, then collection of dead reckoning and GPS signals/data continues. The collection of data may involve filtering, averaging or integrating of data, for example. Odometer signals are typically integrated over time. A slip signal might be averaged over time. Heading and GPS signals may be sampled once per evaluation interval or time averaged.

Detailed Description Text (16):
When the evaluation interval has expired, control passes from decision process 520 to process 522. In process 522 the total accumulated signal from the distance sensor (e.g., a cumulative odometer pulse count over the sample interval) is multiplied by an odometer conversion factor k.sub.1 (See FIG. 4, Ref. No. 402-404), in order to obtain the dead reckoning based distance estimate D.sub.odom for the time interval. Control then passes to process 524. In process 524 a slip estimate is made for the sampling interval. Slip may, for example, be represented as an average value, e.g., a percent of D.sub.odom over the sampling interval. Optionally, control is then passed to process 526. In optional process 526, the dead reckoning distance estimate D.sub.odom may be slip adjusted, as discussed above in FIG. 2. Control is then passed to decision process 528.

Detailed Description Text (17):
In decision process 528 a determination is made as to whether, during the sampling interval, a reliable GPS signal has been obtained. That decision may be based on a number of factors, including the availability and reliability of the GPS signal. GPS velocity vectors with a magnitude less than 1.5 m/s may be deemed unreliable. If a determination is made that the GPS signal is not reliable, then control is passed to decision process 550. In decision process 550, a determination is made as to whether to the dead reckoning derived distance estimate may be relied upon. In the embodiment shown, that decision is based on whether or not to the slip of the vehicle lies above or below a threshold level. If slip is major, i.e., lies above a threshold level, then the dead reckoning distance estimate may not be reliable due to slip induced odometer error. Control is then passed to process 554. In process 554, the navigation system implements processes associated with an inability to update the vehicles position, since neither GPS nor dead reckoning can be relied on in the sampling interval. Control is then passed to process 556 for re-initialization of the dead reckoning system. The vehicle position might be updated using an estimate of distance traveled using previous velocity and heading, for example. Control then returns to decision process 502 and the start of the next estimation interval.

Detailed Description Text (18):
Alternately, if in decision process 550 a determination is made that slip is minor, e.g., below an acceptable threshold, then control is passed to process 552. In process 552 the best estimate as to distance traveled by the vehicle during the sampling interval is set equal to the dead reckoning derived distance estimate, with or without slip correction, as discussed above. GPS is not utilized to produce the best estimate since it is not reliable. Control then passes to process 558.

Detailed Description Text (19):
Alternately, if in decision process 528 a determination is made that during the sampling interval GPS is producing reliable data, then control is passed to process 530. In process 530, a GPS derived distance estimate for the sampling interval is obtained. This may involve an integration of the GPS velocity vector, as discussed above in FIG. 4. Control is then passed to optional decision process 532. In decision process 532, a determination is made as to whether the dead reckoning derived distance estimate lies within an acceptable range of the GPS derived distance estimate. If it does, then control is passed to process 552. In process 552, the best estimate of the distance traveled by the vehicle in the sampling interval, e.g., D.sub.n, is set equal to the dead reckoning derived distance estimate. This may be appropriate since it avoids unnecessary shifts in the vehicle's position resulting from jumping from one to another of the estimating systems, i.e., GPS and dead reckoning. Control is then passed to process 558.

Detailed Description Text (20):
Conversely, if in decision process 532 it is determined that the GPS and dead reckoning derived distance estimates do not substantially match, then control is passed to decision process 534. In decision process 534, a determination is made as to whether the slip experienced by the vehicle during the sampling interval lies below/above an acceptable level. In event that slip is major, e.g., lies above an acceptable level, control is passed to process 538. In process 538, the best distance estimate during the sampling interval is set equal to the GPS derived distance estimate D.sub.g, since the odometer signal contains considerable slip induced inaccuracy. Control is then passed to process 558.

Detailed Description Text (21):
Alternately, if during the sampling interval slip is minor, then control is passed from decision process 534 to process 536. In process 536, the best estimate distance D.sub.n for vehicle travel during the sampling interval is set equal to a weighted sum of the dead reckoning and GPS derived distance estimates, D.sub.r and D.sub.g, respectively. Alternately, in another embodiment of the invention, the best estimate distance might again be set equivalent to the GPS derived distance estimate. In either case, control then passes to process 540.

Current US Original Classification (1):
701/205

Current US Cross Reference Classification (1):
701/213

CLAIMS:

1. A method for navigating a vehicle comprising the acts of:

obtaining during a first time interval an odometer indication signal indicative of a distance traveled by the vehicle, a slip indication signal indicative of the slip of the vehicle, and a heading indication signal indicative of the heading of the vehicle;

converting the odometer indication signal to a first distance estimate;

determining a position of the vehicle based on a known prior position, the first distance estimate obtained during said act of converting and the heading of the vehicle indications of which are obtained during said first act of obtaining;

obtaining during the first time interval an external distance estimate for the vehicle from a radio navigation system;

determining whether the external distance estimate includes indicia of reliability; and

adjusting an odometer conversion parameter utilized in said act of converting if the external distance estimate includes indicia of reliability as determined in said second act of determining.

2. The method for navigating a vehicle of claim 1, further comprising the acts of:

correcting an error in the position of the vehicle determined in said first act of determining if the external distance estimate includes indicia of reliability as determined in said second act of determining.

3. The method for navigating a vehicle of claim 1, further comprising the acts of:

calculating a difference between the adjusted first distance estimate and the external distance estimate; and

correcting an error in the position of the vehicle determined in said first act of determining if the external distance estimate includes indicia of reliability as determined in said second act of determining and the difference as determined in said act of calculating exceeds a first threshold value.

4. The method for navigating a vehicle of claim 1, wherein the converting act further comprises the act of:

correcting the first distance estimate using data derived from the slip indication signal.

5. The method for navigating a vehicle of claim 4, wherein the adjusting act further comprises:

adjusting an odometer conversion parameter utilized in said act of converting if the external distance estimate includes indicia of reliability as determined in said second act of determining and values representative of the slip indication signal obtained in said first act of obtaining fall below a second threshold value.

6. The method for navigating a vehicle of claim 5, wherein the odometer conversion parameter includes a constant proportionate to a ratio of a distance traveled to the number of rotations indicated by the odometer indication signal.

7. The method for navigating a vehicle of claim 6, wherein the converting act further comprises the act of:

multiplying a value representative of the odometer signal by the constant to form the first distance estimate.

8. The method for navigating a vehicle of claim 1, wherein the radio navigation system includes a global positioning satellite sensor which generates the external distance estimate for the vehicle.

11. A vehicle navigation system comprising:

an odometer generating an odometer indication signal indicative of a distance traveled by the vehicle;

a slip sensor generating a slip indication signal indicative of a slip of the vehicle;

a heading sensor generating a heading indication signal indicative of the heading of the vehicle;

a first logic for converting the odometer indication signal to a first distance estimate utilizing an odometer conversion parameter and for determining a position of the vehicle based on a known prior position, the first distance estimate and the heading of the vehicle indications of which are obtained from said heading sensor;

a radio navigation sensor for receiving radio navigation signals; and

a second logic for converting the radio navigation signals to an external distance estimate for the vehicle, for determining whether the external distance estimate includes indicia of reliability; and for adjusting the odometer conversion parameter utilized by said first logic if the external distance estimate includes indicia of reliability.

12. The vehicle navigation system recited in claim 11, wherein the first logic uses data from the slip indication signal to convert the odometer indication signal to a first distance estimate.

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L16: Entry 7 of 10 File: USPT Nov 14, 2000

DOCUMENT-IDENTIFIER: US 6148269 A
TITLE: Wheel diameter calibration system for vehicle slip/slide control

Brief Summary Text (6):
In general, locomotive speed or tangential wheel speed can be calculated from measured motor rotor revolutions per minute ("RPM") values given the diameter of the associated wheel. Conventionally, a speed sensor or revolution counter is coupled to sense the rotational speed of an output shaft of each drive motor. The sensed speed is then converted to a value representative of wheel RPM by multiplying the sensed value in RPM by the gear ratio between the drive motor shaft and wheel/axle set. Tangential wheel speed is then calculated from wheel RPM. For example, a standard 42 inch locomotive wheel has a circumference C equal to .pi. times diameter D or 131.95 inches so that one wheel revolution advances the vehicle by 131.95 inches, assuming zero slip. From this it can be readily determined that a wheel RPM of 200 will produce a locomotive speed of about 25 MPH or, more precisely, about 24.9899 MPH. If the actual wheel diameter is 41.5 inches, the true velocity can be calculated to be 24.6924 MPH which introduces an error of about 0.3 MPH. This speed difference represents an error which produces slip, since the control system regulates based on the assumed ideal diameter, and leads to a loss of tractive effort as well as creating additional wear on the wheels and rails. More importantly, if wheel calibration is in error, the control system will derate (reduce the available tractive or braking effort) when it is not necessary since the system will detect a speed error indicative of a wheel slip or slide.

Brief Summary Text (9):
The present invention is implemented in one form in which a wheel diameter calibration system for a traction vehicle having a plurality of independently powered wheel-axle sets, such as a locomotive, which system allows wheel diameter to be calibrated while the vehicle is in either a tractive effort or electrical braking mode of operation. In the illustrative system, calibration of each wheel-axle set is accomplished by systematically removing power from each wheel-axle set to place that wheel-axle set in a coast mode. The vehicle control initially determines whether a calibration is needed by comparing vehicle velocity as determined by an independent sensor, such as a radar or GPS sensor, to vehicle velocity as determined from a calculation of vehicle speed based upon wheel rotational speed and wheel diameter. If the velocities differ by more than some minimum value, a forced calibration mode is entered. In the forced calibration mode, the control determines first if vehicle tractive effort would be effected if one wheel-axle set were disabled. If not, the one wheel-axle set is disabled, with the commanded tractive effort being distributed over the remaining powered wheel-axle sets. The control thereafter integrates the velocity difference or error while continuously re-computing the error wherein the integrated error value becomes the value of wheel diameter. The control can interrupt the calibration process whenever the disabled wheel-axle set is needed to meet tractive effort requirements. During any interruption in calibration, the last computed value of wheel diameter is maintained so that future calibrations start from the last value thereby allowing calibration to be performed in discontinuous, piecemeal fashion. The control can also accelerate the integration process to perform faster calibration by varying the velocity error signal magnitude by multiplying the error signal by a selectable factor.

Detailed Description Text (10):
It may also be desirable to effect an update over a very short interval, e.g., when the locomotive has traveled over a short distance such as 500 feet. This is accomplished in FIG. 2 by changing the value of the error signal, i.e., if the speed error signal is multiplied by some scale factor, the larger error will effect a more rapid change in the integrator 50 output. For this purpose, a speed reference signal, which may be the tgss signal, is integrated in block 52 to convert the signal from distance per unit time to distance. The integrated distance value is limited, block 54, and then applied as a multiplier to block 48. The reference speed value and the resultant multiplier are preferably reduced in value as wheel diameter approaches a true value (speed error becomes less) so as to reduce high frequency gain and minimize vulnerability to noise and transients.

Detailed Description Text (12):
The summation of the tgss signals and MPH signals in summing junction 58 produces the speed error signal which is coupled to multiplier block 66. As discussed with respect to FIG. 2, the output signal from the block 66 is integrated, block 68, to produce a signal representative of wheel diameter WD. The multiplier M coupled to block 66 scales the error signal so as to control the rate at which wheel diameter is corrected. An estimate of locomotive speed such as the signal is applied to block 70 where the estimate is multiplied by a calibration constant CAL.sub.-- FAST which is selected to establish a number of distance constants. The distance constants act like time constants to set a desired rate at which the value of wheel diameter will be adjusted toward a true value. For example, if the CAL.sub.-- FAST distance constant is set at 100, the wheel diameter will reach 95% of final value when the locomotive has traveled three distance constants or 300 feet.

Detailed Description Text (13):
The signal from multiplier 70 is in miles per hour and in block 72 is converted to feet per second and then applied to integrator block 74. The output of the block 74 is the calibration distance constant X, i.e., the integration process converts the input value in feet per second to an output value in feet. The calibration distance constant is applied to block 76 where it is multiplied by a factor that will result in a closed loop at a time constant of the calibration distance constant divided by speed in feet per second. The value of the multiplication factor depends on an assumed value of wheel diameter. The output of block 76 is the multiplier M which is used in block 66 to adjust the magnitude of the speed error signal in a manner to effect the closed loop calibration in the selected distance.

Detailed Description Text (14):
Note also that the integrator block 74 includes certain limit functions such as maximum and minimum values of calibration distance based on input limits which may be factory set values. Further, the block 74 requires an enable signal when calibration is permitted, i.e., there are certain conditions during which calibration cannot occur and these will be discussed hereinafter. The integrator block 74 also requires a clock input T.sub.CLK as a one second timer input to establish a dt integration interval. Still further, the block 74 is initialized in response to a NEED CALIBRATION signal indicated at block 78.

Detailed Description Text (15):
The integrator block 68 is substantially identical to block 74. The only difference in input control signals is that the block 68 is constrained to maximum and minimum values of wheel diameter whereas integrator 74 is constrained to maximum and minimum values of calibration distance constants.

Current US Cross Reference Classification (2):
701/20

10/721227 A

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L16: Entry 9 of 10 File: USPT Apr 4, 1989

US-PAT-NO: 4819168
DOCUMENT-IDENTIFIER: US 4819168 A

TITLE: Train control having improved wheel wear adjustment for more accurate train operation

DATE-ISSUED: April 4, 1989

INVENTOR-INFORMATION:

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APPL-NO: 07/ 145175 [PALM]
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FIELD-OF-SEARCH: 364/424, 364/426, 246/182R, 246/182A, 246/182B, 246/182C, 180/197

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

Search Selected Search ALL Clear

	PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
☐	4347569	August 1982	Allen, Jr. et al.	364/426
☐	4709194	November 1987	Yagi et al.	364/426 X

ART-UNIT: 252

PRIMARY-EXAMINER: LaRoche; Eugene R.

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ABSTRACT:

A microprocessor control system is provided for a steel wheel vehicle having at least two propulsion/braking units. Each unit operates a truck having a pair of axles each with two steel wheels. A propulsion/braking control includes a microprocessor that applies current commands to respective chopper controls that operate the axle motor drives. Braking command signals operate the associated braking system to apply dynamic and/or friction braking in the braking mode.

16 Claims, 13 Drawing figures

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L16: Entry 9 of 10 File: USPT Apr 4, 1989

DOCUMENT-IDENTIFIER: US 4819168 A
TITLE: Train control having improved wheel wear adjustment for more accurate train operation

Brief Summary Text (3):
Thus, in comparing the speeds of axles for spin/slide control, compensation is required for any difference in the sizes of the wheels. Further, since the ratio of axle speed to vehicle speed changes as wheel size changes, it is preferred that the axle speeds be adjusted so that the axle speeds indicate the vehicle speed.

Brief Summary Text (4):
Wheel size changes also relate to tractive effort control. As wheel size decreases, less tractive effort is required to achieve a particular acceleration rate. Tractive effort adjustment for wheel size changes allows tight tolerances on acceleration and deceleration rates regardless of wheel size. By eliminating excessive tractive effort through control adjustment the frequency of spins and slides is reduced as the wheels wear.

Brief Summary Text (7):
In the prior art, absolute wheel wear compensation has been achieved for tractive effort compensation and linear speed monitoring and control by periodically measuring actual individual wheel sizes and entering the individual wheel sizes into each controller included in the vehicular control system. This procedure is time consuming and it is error prone because each wheel size must be entered in correspondence to the speed input for its axle.

Brief Summary Text (11):
A spin/slide control adjusts the propulsion/braking control in accordance with differential axle speeds to avoid vehicular spins/slides. Means are provided for generating a signal representative of the speed of each axle and for generating a signal representative of an entered actual wheel size for a preselected axle.

Brief Summary Text (12):
Speed adjust factors are computed for the respective axles from the entered actual wheel size, the base wheel sizes and the axle speeds. Means are provided for adjusting the respective axle speeds in accordance with the speed adjust factors and for applying the adjusted axle speeds to the spin/slide control for computation of differential axle speeds with wheel wear compensation.

Brief Summary Text (13):
Tractive effort adjust factors are computed for the respective propulsion/braking units from the actual wheel size, the base wheel sizes and the axle speeds. Means are provided for applying the tractive effort adjustment factors to the propulsion/braking control for computation of tractive effort with wheel wear compensation.

Detailed Description Text (4):
In operation, simultaneous equal wheel wear causes inaccurate tractive effort control in the absence of corrective adjustment. Differential wheel wear causes inaccuracy in tractive effort and spin/slide control in the absence of corrective

adjustment. Wheel-wear control error basically results from the changing relationship between rotational axle speed and linear vehicle speed with decreasing wheel radius.

Detailed Description Text (15):
In accordance with the invention, the tractive effort request is also compensated at this point in this embodiment for wheel wear. The wheel wear compensation is accurately computed on the basis of a tractive effort adjustment factor preferably computed in block 74 from a single actual wheel size entry made through terminal block 76. Thus, when a new measurement has been taken on a preselected axle, the size is entered manually through input terminal block 76.

Detailed Description Text (19):
In a monitoring channel, block 86 computes the distance traveled from the wheel wear adjusted car speed. Odometer 88 is thus accurately updated on a continuing basis.

Detailed Description Text (38):
For monitoring purposes, block 190 calculates the average of the four compensated channel speeds. In block 191, travelled distance is computed as the product of the average speed and the time change over the count period and provided as an output to the car odometer.

Detailed Description Text (40):
In implementing the principles of the invention, the preferred embodiment employs a reference or "fifth" wheel concept to adjust axle speeds and tractive efforts as a function of wheel size. In this manner, the operator need only measure the size of two wheels (one axle) on a car and enter the average of the two measured sizes into the controller. By enabling wheel wear adjustment to be achieved with entry of only one wheel size, the risk of operator error is greatly reduced.

Detailed Description Text (41):
With multiple controllers, the controller that receives the input from the operator sends the input to the other controllers subject to at least one speed signal being common to all of the controllers. Each controller uses the entered wheel size to create a fifth wheel speed which is ratioed to sampled axle speed to compute the speed adjustment factors. Accordingly, the speed adjustment factors are proportional to wheel size and the adjusted axle speeds are the vehicle speed. Since the speed adjustment factors are proportional to wheel size, they are used to adjust correctively the tractive effort applied to the axles.

Detailed Description Text (43):
where base wheel size is usually the unworn wheel size and wheel size input is less than or equal to the base wheel size.

Detailed Description Text (47):
The average size of two wheels on a predetermined axle is applied as an input to block 200. Blocks 200, 202, 204 and 206 determine the speed adjustment factor for the respective speed channels. Block 200 determines the "fifth" wheel speed which is used in computing the speed adjustment factors for the axles other than the axle for which a new wheel size has been input. Block 208 computes a tractive effort wheel wear adjustment factor as the average of the adjustment factors for channels one and two.

Detailed Description Text (56):
When the car is essentially at rest, the adjustment factor calculations are begun in block 224. Specifically, a reference sample car speed called the "fifth" axle car speed is calculated by multiplying the sample car speed (block 220) for the axle for which the new wheel size was input against the ratio of the new wheel size to the base (original) wheel size. Car speed for an axle is defined as the actual

axle speed multiplied against the wheel diameter and against a constant K for converting revolution per minute and inch dimensions to miles per hour.

Detailed Description Text (57):
Typically, the dimension used for size can be the diameter of the wheel. Further, since the two wheels on an axle are interlocked, it is preferred that the size or diameter of both wheels be measured and averaged in providing the input wheel size.

Detailed Description Text (58):
Block 226 calculates the speed adjustment factors (SAF) for all axles. The SAF for the axle for which the new wheel size was entered is equal to the ratio of the new wheel size to the base (original) wheel size. The SAF for all other axles is calculated by ratioing the "fifth" axle speed to the sampled speed for the axle being calculated. All initialization for tachometer circuitry and processing is based on the base wheel size (diameter). Tachometer system outputs thus are inaccurate as the wheels wear and correct actual axle speed is obtained by multiplying the tachometer indicated speed against the ratio of the new wheel diameter to the base wheel diameter.

Detailed Description Text (60):
If block 228 indicates that a new wheel size has been input for the current cycle of the routine 209, block 230 calculates the tractive effort adjustment factor for the truck handled by the control logic 28 or 29 or 30 being executed. The tractive effort adjustment factor (for propulsion or braking) is preferably made equal to the average of the speed adjustment factors for the two axles on the truck for which calculations are being made.

Detailed Description Text (61):
Generally the amount of tractive effort needed to accelerate or decelerate the car at a given rate decreases with wheel wear. Preferably, the tractive effort adjustment factor is recalculated only when a new wheel size is entered. In this manner, more tractive effort than is required may be requested as wheel wear progresses after a new wheel size has been entered. However, implementation of less than requested tractive effort is avoided as might otherwise occur if the tractive effort adjustment factor is updated on an ongoing basis from speed adjustment factor updatings in box 226. Thus, it is desirable that new wheel size values be entered to keep the control system tuned in its accuracy of operation to the actual progress of wheel wear. Accurate system operation can thus be conveniently achieved since the system requires only a single wheel size entry without error proneness.

Detailed Description Text (62):
Once the tractive effort adjustment calculations are made after a new wheel size entry, these calculations are not made again during cycling of the routine 209 until the next wheel size input is made. This is because the tractive effort adjustment factor is preferably updated only on the basis of current absolute wheel size as previously indicated.

Detailed Description Text (64):
Continued recycling of the routine 209 in the time period between wheel size inputs results in recalculation of car speed adjustment factors in block 226. As the wheels continue to wear, relative adjustments are made in the speed adjustment factors for differential amounts of wear among the wheels. Thus, the fifth axle car speed continues to be calculated from the next previous wheel size input, and each axle speed adjustment factor is the ratio of the current fifth axle car speed to the current axle car speed thereby enabling different adjustments for different wheel wears. Accordingly, even in the absence of an external wheel size input, the disclosed system performs at least as well as the prior art.

Detailed Description Paragraph Equation (1):

5TH AXLE SPEED=SPEED OF AXLE FOR WHICH WHEEL SIZE IS INPUT * WHEEL SIZE INPUT/BASE WHEEL SIZE

Detailed Description Paragraph Equation (2):
SPEED ADJUST FACTOR FOR AXLE FOR WHICH WHEEL SIZE IS INPUT =WHEEL SIZE INPUT/BASE WHEEL SIZE

Current US Original Classification (1):
701/19

CLAIMS:

1. A control system for a steel wheel vehicle having at least two propulsion/braking units with each operating at least one axle, said system comprising:

a propulsion/braking control generating current signals to operate the axle motor drives and generating braking signals to operate the associated braking system in accordance with command signals;

a spin/slide control for adjusting said propulsion/braking control in accordance with differential axle speeds to avoid vehicular spins/slides;

means for generating a signal representative of the speed of each axle;

means for generating a signal representative of an entered actual wheel size for a preselected one of said axles;

means for computing speed adjust factors, for the respective axles from the entered actual wheel size, the base wheel sizes and the axle speeds;

means for adjusting the respective axle speeds in accordance with the speed adjust factors and for applying the adjusted axle speeds to said spin/slide control for computation of differential axle speeds with wheel wear compensation;

means for computing tractive effort adjust factors for the respective propulsion/braking units from the actual wheel size, the base wheel sizes and the axle speeds; and

means for applying the tractive effort adjustment factors to said propulsion/braking control for computation and execution of tractive effort with wheel wear compensation.

2. A control system for a steel wheel vehicle having at least two propulsion/braking units with each operating at least one axle, said system comprising:

a propulsion/braking control generating current signals to operate the axle motor drives and generating braking signals to operate the associated braking system in accordance with command signals;

a spin/slide control for adjusting said propulsion/braking control in accordance with differential axle speeds to avoid vehicular spins/slides;

means for generating a signal representative of the speed of each axle;

means for generating a signal representative of an entered actual wheel size for a preselected one of said axles;

means for computing speed adjust factors for the respective axles from the entered

actual wheel size, the base wheel sizes and the axle speeds; and

means for adjusting the respective axle speeds in accordance with the speed adjust factors and for generating an indication of the wheel wear compensated vehicle speed from the adjusted axle speeds and for generating an indication of distance travelled from the calculated vehicle speed.

3. A control system for a steel wheel vehicle having at least two propulsion/braking units with each operative with at least one axle, said system comprising:

a propulsion/braking control generating current signals to operate the axle motor drives and generating braking signals to operate the associated braking system in accordance with command signals;

a spin/slide control for adjusting said propulsion/braking control in accordance with differential axle speeds to avoid vehicular spins/slides;

means for generating a signal representative of the speed of each axle;

means for generating a signal representative of an entered actual wheel size for a preselected one of said axles;

means for computing speed adjust factors for the respective axles from the entered actual wheel size, the base wheel sizes and the axle speeds;

means for adjusting the respective axle speeds in accordance with the speed adjust factors and for applying the adjusted axle speeds to said spin/slide control for computation of differential axle speeds with wheel wear compensation;

means for generating an indication of the wheel wear compensated vehicle speed from the adjusted axle speeds and for generating an indication of distance travelled from the calculated vehicle speed;

means for computing tractive effort adjust factors for the respective propulsion/braking units from the actual wheel size, the base wheel sizes and the axle speeds; and

means for applying the tractive effort adjustment factors to said propulsion/braking control for computation and execution of tractive effort with wheel wear compensation.

4. A train control as set forth in claim 1 wherein the speed adjust factors are computed cyclically and the tractive effort adjust factor is computed once after each new wheel size is input.

6. A train control as set forth in claim 1 wherein a reference axle speed is computed from the product of the axle speed for which the wheel size is input and the ratio of the wheel size input to the original wheel size, the speed adjust factor for the axle for which the wheel size is input is computed as the ratio of the wheel size input to the original wheel size, the speed adjust factor for other axles is computed as the ratio of the reference axle speed to the measured axle speed, and the tractive effort adjust factor for each propulsion/braking unit is a function of the speed adjust factor or factors for the axle or axles associated with the unit.

9. A train control as set forth in claim 1 wherein the wheel size for the selected axle is the average wheel size for the two wheels on the axle.

10. A train control as set forth in claim 2 wherein the travelled vehicle distance

is computed from vehicle speed derived as the average of the wheel wear compensated axle speeds.

11. A train control as set forth in claim 3 wherein the speed adjust factors are computed cyclically and the tractive effort adjust factor is computed once after each new wheel size is input.

12. A train control as set forth in claim 5 wherein the speed adjust factors are computed cyclically and the tractive effort adjust factor is computed once after each new wheel size is input.

13. A train control as set forth in claim 6 wherein the speed adjust factors are computed cyclically and the tractive effort adjust factor is computed once after each new wheel size is input.

14. A train control as set forth in claim 7 wherein the speed adjust factors are computed cyclically and the tractive effort adjust factor is computed once after each new wheel size is input.

15. A train control as set forth in claim 8 wherein the speed adjust factors are computed cyclically and the tractive effort adjust factor is computed once after each new wheel size is input.

16. A train control as set forth in claim 9 wherein the speed adjust factors are computed cyclically and the tractive effort adjust factor is computed once after each new wheel size is input.

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